VOL. XII, PARTS II AND III *Published* 30 *June*, 1927

The British Mycological Society

(*Recognosce notum, ignotum inspice*)

TRANSACTIONS

Edited by

CARLETON REA and J. RAMSBOTTOM

Price to non-members, Fifteen Shillings net

CAMBRIDGE UNIVERSITY PRESS
LONDON: FETTER LANE, E.C. 4
ALSO
H. K. LEWIS AND CO., LTD., 136, GOWER STREET, LONDON, W.C. 1
WHELDON AND WESLEY, LTD., 2–4, ARTHUR STREET, NEW OXFORD STREET
LONDON, W.C. 2
CHICAGO: THE UNIVERSITY OF CHICAGO PRESS
(AGENT FOR THE UNITED STATES)
BOMBAY, CALCUTTA, MADRAS: MACMILLAN & CO., LTD.
TOKYO: THE MARUZEN-KABUSHIKI-KAISHA

PRINTED IN GREAT BRITAIN

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THE HEREFORD FORAY.

By E. M. Wakefield.

Sept. 27th to Oct. 2nd, 1926.

THE thirtieth Autumn Fungus Foray and Annual General Meeting was held at Hereford from September 27th to October 2nd, about fifty members being present. As headquarters for meetings the Woolhope Club Room at the Public Library was available, and space for the exhibition of specimens was provided in the Museum in the same building.

On the Monday evening, Col. M. J. G. Scobie, the President of the Woolhope Club, extended to the Society an official welcome to Hereford, referring to the historical connection between the two Societies. Dr Pethybridge replied on behalf of the Society. Following upon this pleasant formality the Annual General Meeting was held. Dr E. J. Butler was elected President for 1927, with Miss A. Lorrain Smith as second Vice-President. Messrs H. H. Knight and E. W. Mason were elected to the Council. It was decided that the Autumn Foray in 1927 should be held in Scotland, the details to be arranged in conjunction with the Scottish Cryptogamic Society.

On Tuesday, collecting began with a whole day's excursion to Wormesley and Credenhill. *Cheilymenia dalmeniensis* and *Androsaceus Hudsonii* were secured soon after entering the grounds of Wormesley Grange, and *Ganoderma resinaceum* was also collected there. At Credenhill were found amongst numerous other species *Russula lilacea, Inocybe pyriodora, I. conformata, I. corydalina, Cortinarius purpurascens*, and *Eichleriella spinulosa*. In the evening Dr Pethybridge delivered his Presidential address, on "Mycology and Plant Pathology." The meeting was held, by kind invitation of Miss Bull, in the rooms at her house where the Woolhope Club used to meet when Dr Bull was one of its leading spirits.

On the Wednesday, the woods on Dinmore Hill were visited. The woods have unfortunately been much cut, and the ground proved to be rather poor in Agarics, but on the north side numerous resupinate Hymenomycetes were found, including *Corticium byssinum* and *Tomentellina ferruginosa*, both of which are new to Britain. The trees were mostly oak and sweet chestnut, and on rotten fallen branches *Femsjonia luteoalba* was particularly abundant. Mr Ashby picked up a *Hypoxylon* which was later identified by Mr E. W. Mason as the rare *Hypoxylon argillaceum*. Other species found on this day were *Leptopodia*

ephippium, *Poria eupora*, *P. purpurea* and *Corticium atrovirens*, and Dr Bayliss Elliott reported later *Ctenomyces serratus*, *Hypocrea gelatinosa*, and *Rosellinia mammoidea*.

After the return to Hereford the party paid a visit to the cider works of Messrs Bulmer, and were shown over the factory by the Mayor of Hereford and Dr Durham (chemist to the firm). In the evening Mr Ramsbottom gave a public lecture on the larger fungi, illustrated by coloured lantern slides.

Thursday's excursion was to Moccas Old Park, which proved ideal hunting-ground. The park is remarkable for its fine old trees, and the many fallen, undisturbed trunks provided ample occupation for mycologists. The ground proved very rich in Clavarias, in spite of a rather dense undergrowth of bracken. *Clavaria Kunzii* and its dwarf form *C. Krombholzii* were abundant. *C. amethystina*, *C. tenuipes*, and *C. gigaspora* were also secured, the latter being only the second record of this species. Hygrophori were also abundant: *Hygrophorus intermedius*, *H. Reai*, *H. calyptraeformis*, and a new species, *H. lepidopus*, were found in addition to the more common species.

In the evening the Society was entertained at dinner by the Woolhope Club at the Green Dragon Hotel, the occasion being a celebration of the seventy-fifth anniversary of the Club.

On the Friday, Haugh Wood, Mordiford, and the grounds at Holme Lacy were visited, but neither locality was very productive. *Lactarius vellereus* was remarkable for its abundance at Holme Lacy. Other finds were *Lactarius controversus*, *Omphalia atropuncta*, *Boletus nigrescens*, *Ganoderma lucidum*, *Corticium fastidiosum*, and *Kuehneola albida*. The day finished with a pleasant visit to Dr Durham's house, where tea was provided.

In the evening the President exhibited a new potato tuber rot due to *Rosellinia necatrix*, and mentioned that the same fungus has been found attacking narcissus bulbs in the Scilly Isles.

Mr Carleton Rea commented on the finds of the week.

The meeting concluded with votes of thanks to the Woolhope Club and in particular to Dr Durham and Miss Bull; and to the various landowners who had given permission for their ground to be worked.

The subjoined list of species collected is the result of the work of many members. In particular the writer is specially indebted to Mr Rea, Mr Ramsbottom, Mr Pearson, Mr Buddin, and Dr Bayliss Elliott.

Species marked as being collected at Hereford were obtained from Dr Durham's garden. Those from Ross were brought in by Mr F. A. Mason on the first day of the meeting. Species marked with an asterisk are new to Britain.

Complete List of Species collected during the Foray.

C. = Credenhill; *D.* = Dinmore; *H.* = Haugh Wood; *L.* = Holme Lacy; *M.* = Moccas Old Park; *W.* = Wormesley.

HYMENOMYCETES.

Amanita phalloides (Vaill.) Fr., *C.*, *D.*, *H.*, pantherina (DC.) Fr., *D.*, rubescens (Pers.) Fr., *M.*

Amanitopsis vaginata (Bull.) Roze, *L.*, fulva (Schaeff.) W. G. Sm., *D.*, *M.*

Lepiota rhacodes (Vitt.) Fr., *W.*, constricta (Fr.) Quél., *M.*, amianthina (Scop.) Fr., *M.*

Armillaria mellea (Vahl) Fr., *C.* (rhizomorphs only), *W.*, *H.*, mucida (Schrad.) Fr., *M.*

Tricholoma sejunctum (Sow.) Fr., *D.*, resplendens Fr., *D.*, fulvum (DC.) Fr., *C.*, albobrunneum (Pers.) Fr., *W.*, rutilans (Schaeff.) Fr., *C.*, argyraceum (Bull.) Fr., *M.*, cuneifolium Fr., *M.*, *H.*, *L.*, saponaceum Fr., *D.*, carneum (Bull.) Fr., *W.*, acerbum (Bull.) Fr., *D.*, cinerascens (Bull. non Fr.) Quél., *W.*

Russula chloroides (Krombh.) Bres., *W.*, *D.*, nigricans (Bull.) Fr., *W.*, *D.*, *M.*, adusta (Pers.) Fr., *D.*, incarnata Quél., *W.*, virescens (Schaeff.) Fr., *M.*, lepida Fr., *C.*, *D.*, *M.*, cyanoxantha (Schaeff.) Fr., *C.*, *D.*, *M.*, lilacea Quél., *C.*, foetens (Pers.) Fr., *L.*, ochroleuca (Pers.) Fr., *C.*, fellea Fr., *C.*, rosacea (Pers.) Fr., *M.*, fragilis (Pers.) Fr., *W.*, *D.*, *M.*, and var. fallax (Schaeff.) Massee, *L.*, emetica (Schaeff.) Fr., *D.*, atropurpurea (Krombh.) Maire, *W.*, *D.*, *H.*, xerampelina (Schaeff.) Fr., *M.*, *L.*, puellaris Fr., *W.*, punctata (Gill.) Maire, *M.*

Mycena pelianthina Fr., *M.*, pura (Pers.) Fr., *C.*, *M.*, flavo-alba Fr., *M.*, rugosa Fr., *C.*, *D.*, galericulata (Scop.) Fr., *D.*, *H.*, *L.*, polygramma (Bull.) Fr., *D.*, *M.*, *H.*, ammoniaca Fr., *M.*, *L.*, metata Fr., *M.*, vitilis Fr., *W.*, *M.*, acicula (Schaeff.) Fr., *D.*, haematopus (Pers.) Fr., *M.*, sanguinolenta (A. & S.) Fr., *W.*, *D.*, galopus (Pers.) Fr., *W.*, *D.*, *L.*, stylobates (Pers.) Fr., *W.*, *D.*

Collybia radicata (Relh.) Berk., *C.*, *H.*, platyphylla (Pers.) Fr., *W.*, fusipes (Bull.) Berk., *C.*, *D.*, *L.*, and var. oedematopus (Schaeff.) Fr., *W.*, maculata (A. & S.) Fr., *D.*, velutipes (Curt.) Fr., *C.*, tuberosa (Bull.) Fr., *D.*

Marasmius peronatus (Bolt.) Fr., *C.*, *D.*, erythropus (Pers.) Fr., *W.*, *C.*, *M.*, hariolorum (DC.) Quél., *C.*, dryophilus (Bull.) Karst., *W.*, *C.*, *D.*, *M.*, *L.*, *H.*, and var. aquosus (Bull.) Rea, *W.*, *C.*, foetidus (Sow.) Fr., *C.*, ramealis (Bull.) Fr., *W.*, *C.*, *D.*, *H.*

Androsaceus rotula (Scop.) Pat., *M.*, *W.*, Hudsonii (Pers.) Pat., *W.*

Lactarius torminosus (Schaeff.) Fr., *W.*, *D.*, turpis (Weinm.) Fr., *D.*, controversus (Pers.) Fr., *L.*, pubescens Fr., *W.*, blennius Fr., *M.*, pyrogalus (Bull.) Fr., *M.*, *L.*, chrysorheus Fr., *D.*, piperatus (Scop.) Fr., *D.*, vellereus Fr., *W.*, *C.*, *D.*, *H.*, *L.*, quietus Fr., *W.*, *D.*, *M.*, vietus Fr., *W.*, rufus (Scop.) Fr., *D.*, glyciosmus Fr., *W.*, fuliginosus Fr., *D.*, serifluus (DC.) Fr., *M.*, mitissimus Fr., *C.*, subdulcis (Pers.) Fr., *D.*, *M.*

Hygrophorus eburneus (Bull.) Fr., *Ross*, cossus (Sow.) Fr., *H.*, pratensis (Pers.) Fr., *W.*, *M.*, virgineus (Wulf.) Fr., *M.*, *L.*, niveus (Scop.) Fr., *C.*, *M.*, clivalis Fr., *M.*, ovinus (Bull.) Fr., *L.*, *lepidopus Rea, *M.*, laetus (Pers.) Fr., *M.*, coccineus (Schaeff.) Fr., *M.*, Reai Maire, *M.*, turundus Fr., *M.*, puniceus Fr., *M.*, intermedius Pass., *M.*, conicus (Scop.) Fr., *M.*, calyptraeformis Berk., *W.*, chlorophanus Fr., *W.*, *M.*, psittacinus (Schaeff.) Fr., *W.*, *D.*, *M.*, unguinosus Fr., *M.*

Clitocybe clavipes (Pers.) Fr., *M.*, aurantiaca (Wulf.) Studer, *W.*, *M.*, odora (Bull.) Fr., *C.*, *D.*, dealbata (Sow.) Fr., *D.*, *H.*, *M.*, infundibuliformis (Schaeff.) Fr., *W.*, *D.*, *M.*, *L.*, and var. membranacea (Fl. Dan.) Fr., *W.*, incilis Fr., *M.*, flaccida (Sow.) Fr., *W.*, fragrans (Sow.) Fr., *W.*

Laccaria laccata (Scop.) Berk. & Br., *W.*, *D.*, *M.*, and var. amethystina (Vaill.) Berk. & Br., *C.*

Omphalia rustica Fr., *M.*, atropuncta (Pers.) Quél., *H.*, fibula (Bull.) Fr., *M.*, and var. Swartzii Fr., *M.*

Pleurotus sapidus Schulz., *W.*, acerosus Fr., *M.*, applicatus (Batsch) Berk., *M.*

Cantharellus cibarius Fr., *W.*, *D.*, cinereus (Pers.) Fr., *H.*
Craterellus cornucopioides (Linn.) Fr., *D.*
Dictyolus muscigenus (Bull.) Quél., *D.*
Lentinus cochleatus (Pers.) Fr., *W.*, *M.*
Panus torulosus (Pers.) Fr., *W.*, *C.*, stipticus (Bull.) Fr., *W.*, *H.*
Pluteus cervinus (Schaeff.) Fr., *W.*, *D.*, salicinus (Pers.) Fr., *D.*, *M.*, nanus (Pers.) Fr., *M.*, and var. lutescens Fr., *M.*
Entoloma sinuatum Fr., *M.*, lividum (Bull.) Fr., *D.*, *L.*, jubatum Fr., *D.*, *M.*, sericeum (Bull.) Fr., *M.*, *L.*, nidorosum Fr., *D.*, *M.*
Nolanea pascua (Pers.) Fr., *M.*, papillata Bres., *M.*
Clitopilus prunulus (Scop.) Fr., *D.*, *H.*
Claudopus variabilis (Pers.) W. G. Sm., *M.*
Paxillus involutus (Batsch) Fr., *W.*, *D.*, *L.*
Pholiota erebia Fr., *M.*, radicosa (Bull.) Fr., *D.*, squarrosa (Müll.) Fr., *M.*, spectabilis Fr., *D.*, *M.*, mutabilis (Schaeff.) Fr., *D.*, *M.*, marginata (Batsch) Fr., *W.*, *M.*
Bolbitius titubans (Bull.) Fr., *L.*
Inocybe pyriodora (Pers.) Fr., *C.*, *Ross*, rimosa (Bull.) Fr., *M.*, *L.*, corydalina Quél., *C.*, geophylla (Sow.) Fr., *W.*, *M.*, *L.*, and var. lilacina Fr., *C.*, *M.*, conformata Karst., *C.*, cincinnata Fr., *M.*
Astrosporina asterospora (Quél.) Rea, *M.*, *L.*, petiginosa (Fr.) Rea, *D.*
Hebeloma fastibile Fr., *W.*, crustuliniforme (Bull.) Fr., *D.*, *M.*, *H.*, *L.*, longicaudum (Pers.) Fr., *L.*
Naucoria escharoides Fr., *W.*
Galera tenera (Schaeff.) Fr., *M.*, *H.*, *L.*, hypnorum (Schrank) Fr., *D.*, *M.*
Tubaria furfuracea (Pers.) W. G. Sm., *W.*, *D.*, *M.*, *H.*, inquilina (Fr.) W. G. Sm., *W.*, *D.*
Flammula sapinea Fr., *C.*, *L.*, ochrochlora Fr., *W.*, *D.*, *H.*, gummosa (Lasch) Fr., *C.*
Cortinarius (Phlegmacium) largus Fr., *D.*, purpurascens Fr., *C.*
Cortinarius (Myxacium) arvinaceus Fr., *C.*, elatior Fr., *W.*, *C.*, *D.*
Cortinarius (Dermocybe) tabularis (Bull.) Fr., *W.*, caninus Fr., *H.*, lepidopus Cooke, *W.*
Cortinarius (Telamonia) torvus Fr., *D.*, armillatus Fr., *D.*, hinnuleus (Sow.) Fr., *M.*, *L.*, brunneus (Pers.) Fr., *L.*, incisus (Pers.) Fr., *D.*, paleaceus (Weinm.) Fr., *D.*
Cortinarius (Hydrocybe) duracinus Fr., *W.*
Crepidotus mollis (Schaeff.) Fr., *W.*, *M.*
Psaliota arvensis (Schaeff.) Fr., *C.*, campestris (Linn.) Fr., *H.*, villatica (Brond.) Magn., *W.*, haemorrhoidaria Kalchbr., *M.*, comtula Fr., *M.*
Stropharia aeruginosa (Curt.) Fr., *W.*, *D.*
Anellaria separata (Linn.) Karst., *W.*, *M.*
Gomphidius viscidus (Linn.) Fr., *W.*
Hypholoma sublateritium (Schaeff.) Fr., *D.*, *H.*, capnoides Fr., *C.*, fasciculare (Huds.) Fr., *W.*, *C.*, *D.*, *M.*, *H.*, *L.*, pyrotrichum (Holmsk.) Fr., *Ross*, *C.*, *M.*, velutinum (Pers.) Fr., *W.*, *L.*, appendiculatum (Bull.) Fr., *D.*
Panaeolus sphinctrinus Fr., *W.*, campanulatus (Linn.) Fr., *M.*
Psathyrella disseminata (Pers.) Fr., *C.*
Psilocybe ericaea (Pers.) Fr., *M.*, uda (Pers.) Fr., *W.*, semilanceata Fr , *W.*, *M.*, *L.*
Coprinus atramentarius (Bull.) Fr., *W.*, *Ross*, niveus (Pers.) Fr., *M.*, *H.*, *L.*, plicatilis (Curt.) Fr., *W.*, *M.*, *H.*
Boletus luteus (Linn.) Fr., *D.*, elegans (Schum.) Fr., *W.*, *L.*, chrysenteron (Bull.) Fr., *W.*, *C.*, *D.*, *L.*, subtomentosus (Linn.) Fr., *W.*, *C.*, *M.*, *L.*, versicolor Rostk., *M.*, edulis (Bull.) Fr., *D.*, reticulatus (Schaeff.) Boud., *M.*, impolitus Fr., *D.*, pachypus Fr., *W.*, luridus (Schaeff.) Fr., *D.*, *W.*, erythropus (Pers.) Quél., *W.*, *D.*, purpureus Fr., *W.*, versipellis Fr., *D.*, scaber (Bull.) Fr., *W.*, *D.*, nigrescens Roze & Rich., *D.*, *H.*
Strobilomyces strobilaceus (Scop.) Berk., *D.*
Polyporus nummularius (Bull.) Quél., *W.*, picipes Fr., *L.*, squamosus (Huds.) Fr., *D.*, *M.*, intybaceus Fr., *W.*, sulphureus (Bull.) Fr., *W.*, *M.*, *L.*, giganteus (Pers.) Fr., *C.*, *W.*, *M.*, betulinus (Bull.) Fr., *C.*, *D.*, *M.*, *L.*, dryadeus (Pers.) Fr., *W.*, *D.*, *H.*, hispidus (Bull.) Fr., *H.*, amorphus Fr., *C.*, *M.*,

adustus (Willd.) Fr., *W.*, *C.*, *D.*, fragilis Fr., *D.*, caesius (Schrad.) Fr., *W.*, *D.*, stipticus (Pers.) Fr., *W.*, *M.*
Fomes ferruginosus (Schrad.) Massee, *M.*, ulmarius (Sow.) Fr., *W.*, *M.* on *Aesculus Hippocastanum*, *L.*, annosus Fr., *C.*, *H.*, connatus Fr., *W.*
Ganoderma lucidum (Leyss.) Karst., *H.*, applanatum (Pers.) Pat., *M.*, *L.*, *Ross*, resinaceum Boud., *W.*, *L.*
Poria eupora Karst., *D.*, hymenocystis Berk. & Br., *D.*, *M.*, purpurea Fr., *D.*
Polystictus hirsutus (Wulf.) Fr., *M.*, versicolor (Linn.) Fr., *W.*, *D.*, *M.*, *L.*
Irpex obliquus (Schrad.) Fr., *W.*, *D.*, *M.*, *H.*
Lenzites betulina (Linn.) Fr., *W.*, *D.*
Trametes gibbosa (Pers.) Fr., *C.*, mollis (Sommerf.) Fr., *M.*
Daedalea biennis (Bull.) Quél., *C.*, *D.*, *M.*, *H.*
Merulius tremellosus (Schrad.) Fr., *W.*, *M.*
Phlebia merismoides Fr., *D.*
Fistulina hepatica (Huds.) Fr., *C.*, *D.*, *M.*, *H.*, *L.*
Hydnum repandum (Linn.) Fr., *W.*, *D.*, and var. rufescens (Pers.) Fr., *D.*
Acia uda (Fr.) Bourd. & Galz., *W.*, *C.*, fusco-atra (Fr.) Pat., *C.*, *D.*
Grandinia helvetica (Pers.) Fr., *C.*, *D.*
Odontia fimbriata (Pers.) Fr., *C.*, barba-Jovis (With.) Fr., *D.*, farinacea (Pers.) Quél., *D.*
Hypochnus ferrugineus (Pers.) Fr., *C.*, *D.*, *M.*, fuscus (Pers.) Fr., *D.*, subfuscus Karst., *M.*, rubiginosus Bres., *D.*, fumosus Fr., *D.*
*Tomentellina ferruginosa v. Hoehn. & Litsch., *D.*
Stereum spadiceum Fr., *W.*, sanguinolentum (A. & S.) Fr., *D.*, hirsutum (Willd.) Fr., *W.*, *C.*, *D.*, *M.*, *H.*
Hymenochaete rubiginosa (Dicks.) Lév., *M.*
Corticium fuciforme (Berk.) Wakef. on *Festuca ovina*, *H.*, arachnoideum Berk., *D.*, *byssinum (Karst.) Massee, *D.*, atrovirens Fr., *D.*, botryosum Bres., *D.*, flavescens (Bon.) Massee, *M.*, confine Bourd. & Galz., *D.*, *M.*, fastidiosum (Fr.) Bourd. & Galz., *H.*, porosum Berk. & Curt., *D.*
Peniophora Aegerita v. Hoehn. & Litsch., *W.*, subalutacea (Karst.) v. Hoehn. & Litsch., *D.*, sanguinea (Fr.) Bres., *D.*, velutina (DC.) Cooke, *C.*, *D.*, *M.*, setigera (Fr.) Bres., *C.*, *D.*, hydnoides Cooke & Massee, *D.*, cinerea (Fr.) Cooke, *M.*, quercina (Pers.) Cooke, *C.*, *D.*, *M.*, *L.*
Coniophora puteana Fr., *D.*
Cyphella capula (Holmsk.) Fr., *W.*
Clavaria cristata (Holmsk.) Fr., *M.*, cinerea (Bull.) Fr., *C.*, *D.*, *M.*, gigaspora Cotton, *M.*, amethystina (Batt.) Fr., *M.*, rugosa (Bull.) Fr., *C.*, *M.*, Kunzei Fr. (together with a dwarfed form which is C. Krombholzii Fr.), *M.*, corniculata (Schaeff.) Fr., *M.*, fusiformis (Sow.) Fr., *W.*, *M.*, luteoalba Rea, *M.*, inaequalis (Müll.) Fr., *W.*, *M.*, *H.*, vermicularis Fr., *M.*, pistillaris (Linn.) Fr., *H.*, tenuipes Berk. & Br., *M.*
Auricularia mesenterica (Dicks.) Fr., *C.*, *L.*, auricula-Judae (Linn.) Schroet., *D.*
Tremella mesenterica (Retz.) Fr., *C.*, *D.*, *H.*
Exidia nucleata (Schw.) Rea, *C.*
Tremellodon gelatinosum (Scop.) Pers., *C.*
Sebacina incrustans (Pers.) Tul., *M.*, *H.*
Eichleriella spinulosa (Berk. & Curt.) Burt, *C.*
Tulasnella (Gloeotulasnella) hyalina v. Hoehn. & Litsch., *C.*
Dacryomyces deliquescens (Bull.) Duby, *W.*, *D.*, chrysocomus (Bull.) Tul., *D.*
Femsjonia luteoalba Fr., *C.*, *D.*
Calocera viscosa (Pers.) Fr., *C.*, cornea (Batsch) Fr., *W.*

GASTEROMYCETES.

Phallus impudicus (Linn.) Pers., *C.*, *D.*, *M.*
Lycoperdon depressum Bon., *C.*, *M.*, *L.*, umbrinum Pers., *W.*, perlatum Pers., *W.*, pyriforme (Schaeff.) Pers., *W.*, *D.*, *H.*
Crucibulum vulgare Tul., *W.*, *D.*
Cyathus striatus (Huds.) Pers., *W.*, *C.*, *D.*, *H.*
Scleroderma aurantium Pers., *M.*, verrucosum (Vaill.) Pers., *C.*, *D.*, *H.*, *L.*
Sphaerobolus stellatus (Tode) Pers., *W.*

UREDINEAE.

Uromyces Fabae (Pers.) de Bary, *Hereford*, Valerianae (Schum.) Fuck., *H.*, Dactylidis Otth., *L.*

Puccinia Violae (Schum.) DC., *D.*, *H.*, Lychnidearum Link, *W.*, Pruni-spinosae Pers., *L.*, *Hereford*, pulverulenta Grev., *W.*, *D.*, Circaeae Pers., *L.*, Aegopodii (Schum.) Mont., *L.*, Saniculae Grev., *D.*, punctata Link, *H.*, obtegens (Link) Tul., *W.*, Cirsii Lasch, *W.*, Taraxaci Plowr., *D.*, Veronicae Schroet. on *V. montana*, *M.*, Glechomatis DC., *W.*, *M.*, *L.*, Menthae Pers., *W.*, *H.*, annularis (Str.) Schlecht., *W.*, Iridis (DC.) Wallr., *D.*, obscura Schroet., *C.*, Caricis (Schum.) Rebent., *M.*, Lolii Niels., *D.*, *L.*, Poarum Niels., *W.* (aecidium).

Phragmidium subcorticium (Schrank) Wint., *H.*, violaceum (Schultz) Wint., *W.*, *L.*

Kuehneola albida Magnus, *H.*

Coleosporium Sonchi-arvensis (Pers.) Lév., *D.*, Tussilaginis (Pers.) Kleb., *W.*

Pucciniastrum Circaeae (Schum.) Schroet., *W.*, *C.*, *D.*, *H.*, *L.*, Epilobii (Pers.) Otth., *W.*

Melampsora Larici-populina Kleb., *D.*, *H.*

Melampsoridium betulinum (Pers.) Kleb., *W.*, *C.*, *D.*

USTILAGINEAE.

Ustilago Scabiosae (Sow.) Wint., *H.*

Sphacelotheca Hydropiperis (Schum.) de Bary, *W.*

Entyloma Ranunculi (Bon.) Schroet., *D.*

PYRENOMYCETES.

Ctenomyces serratus Eidam, *D.*

Sphaerotheca pannosa (Wallr.) Lév., *W.*, *D.*, *H.*, Castagnei Lév. on *Arctium*, *D.*, *H.*

Podosphaera Oxyacanthae (DC.) de Bary, *C.*, *H.*, leucotricha (Ell. & Ev.) Salm., *Hereford*.

Erysiphe Cichoracearum DC. on *Myosotis*, *H.*, Polygoni DC. on *Circaea*, *W.*, *C.*, on *Hypericum*, *D.*, *H.*

Uncinula Aceris (DC.) Sacc., *C.*, *D.*, *H.*

Phyllactinia corylea (Pers.) Karst., *H.*, *L.*

Nectria cinnabarina (Tode) Fr., *H.*, Peziza (Tode) Fr., *M.*

Hypomyces aurantius (Pers.) Tul., *M.*

Hypocrea gelatinosa (Tode) Fr., *D.*, citrina (Pers.) Fr., *D.*

Claviceps purpurea (Fr.) Tul. on *Brachypodium*, *W.*, on *Arrhenatherum* and *Dactylis*, *L.*, on *Avena*, *D.*, microcephala (Wallr.) Wint., *D.*

Cordyceps militaris (Linn.) Link, *D.*

Leptospora spermoides (Hoffm.) Fuck., *M.*, *L.*, ovina (Pers.) Fuck., *M.*

Rosellinia mammoidea Cooke, *D.*

Mycosphaerella maculiformis (Pers.) Schroet., *D.*

Venturia Rumicis (Desm.) Wint., *W.*

Leptosphaeria acuta (Moug. & Nestl.) Karst., *W.*

Melanconis stilbostoma (Fr.) Tul., *H.*

Cryptosphaeria eunomia (Fr.) Fuck., *H.*

Diatrypella quercina (Pers.) Nke., *W.*, *C.*, *D.*

Diatrype Stigma (Hoffm.) de Not., *W.*, *M.*, disciformis (Hoffm.) Fr., *M.*

Hypoxylon multiforme Fr., *D.*, fuscum (Pers.) Fr., *W.*, *H.*, argillaceum (Pers.) Berk., *D.*, coccineum Bull., *M.*

Daldinia concentrica (Bolt.) Ces. & de Not., *W.*, *C.*, *M.*

Xylaria Hypoxylon (Linn.) Grev., *C.*, *L.*, polymorpha (Linn.) Grev., *H.*

Phyllachora graminis (Pers.) Fuck., *W.*

Endodothella Junci (Fr.) Theiss. & Syd., *W.*

Dothidella Ulmi (Duv.) Wint., *L.*

HYSTERIALES.

Dichaena quercina Fr., *M.*

Rhopographus Pteridis (Sow.) Wint., *W.*, *D.*, *M.*

DISCOMYCETES.

Leptopodia ephippium (Lév.) Boud., *D.*
Peziza aurantia Pers., *W.*, *C.*, *D.*
Sarcoscypha coccinea (Jacq.) Fr., *M.*
Ciliaria scutellata (Linn.) Quél., *W.*, *D.*, *M.*, *H.*
Cheilymenia dalmeniensis (Cooke) Boud., *W.*, *D.*
Coprobia granulata (Bull.) Boud., *D.*
Exoascus alnitorquus (Tul.) Sadeb., *W.*
Trichoglossum hirsutum (Pers.) Boud., *M.*
Microglossum viride (Pers.) Gill., *M.*
Leotia lubrica (Scop.) Pers., *C.*
Calycella claroflava (Grev.) Boud., *D.*, *M.*
Coryne sarcoides (Jacq.) Tul., *W.*, *M.*
Bulgaria inquinans (Pers.) Fr., *W.*, *D.*, *M.*
Orbilia luteo-rubella (Nyl.) Karst., *W.*, xanthostigma Fr., *C.*, *M.*
Sclerotinia Curreyana (Berk.) Karst., *M.*
Chlorosplenium aeruginosum (Oeder.) de Not., *D.*
Helotium herbarum (Pers.) Fr., *W.*, *H.*, fructigenum (Bull.) Fuck., *H.*, scutula (Pers.) Karst., *W.*
Cyathicula coronata (Bull.) de Not., *W.*
Dasyscypha virginea (Batsch) Fuck., *W.*, *D.*, pulverulenta (Lib.) Sacc., *D.*
Arachnopeziza aurelia (Pers.) Fuck., *D.*, aurata Fuck., *D.*
Trichoscypha calycina (Schum.) Boud., *L.*
Hyaloscypha hyalina (Pers.) Boud., *D.*
Urceolella puberula (Lasch) Boud., *W.*
Mollisia cinerea (Batsch) Karst., *W.*, *D.*, *M.*, melaleuca (Fr.) Sacc., *D.*
Catinella olivacea (Batsch) Boud., *M.*
Pseudopeziza Trifolii (Biv.-Bern) Fuck., *D.*, Ranunculi (Wallr.) Fuck., *D.*
Stegia Ilicis Fr., *W.*
Rhytisma acerinum (Pers.) Fr., *C.*, *D.*

PHYCOMYCETES.

Syzygites megalocarpus Ehrb., *W.*, *D.*
Phytophthora infestans (Mont.) de Bary, *Hereford.*
Peronospora alta Fuck., on *Plantago media*, *D.*, *H.*

SPHAEROPSIDALES.

Phyllosticta hedericola Dur. & Mont., *H.*
Actinonema Rosae (Lib.) Fr., *D.*, *Hereford.*
Septoria Rubi West., *W.*, *D.*, castanicola Desm., *D.*
Gloeosporium nervisequum (Fuck.) Sacc., *L.*
Libertella faginea Desm., *M.*
Vermicularia trichella Fr., *H.*, Holci Syd., *L.*

HYPHOMYCETES.

Monilia aurea (Link) Gmel., *D.*, *M.*, fructigena Pers., *Hereford*, cinerea Bon., *Hereford.*
Oidium alphitoides Griff. & Maubl., *W.*, *C.*, *D.*, *H.*
Ovularia obliqua (Cooke) Oud., *W.*, *H.*
Rhinotrichum Thwaitesii Berk. & Br., *M.*
Trichoderma viride (Pers.) Fr., *W.*, *D.*
Botrytis cinerea Pers., *Hereford.*
Ramularia calcea (Desm.) Ces., *W.*, *C.*, *D.*, *M.*, *L.*, Epilobii Allesch., *D.*, Circaeae Allesch., *D.*, plantaginea Sacc. & Berl., *D.*, Primulae Thuem., *W.*, *D.*, *H.*, sambucina Sacc., *W.*, Urticae Ces., *W.*, Taraxaci Karst., *D.*, *H.*
Bispora monilioides Corda, *C.*, *H.*
Hormodendron cladosporioides (Fres.) Sacc., *H.*
Fusicladium dendriticum Fuck., *D.*
Heterosporium gracile Sacc., *D.*
Cercospora Mercurialis Pass., *C.*
Stilbella erythrocephala (Ditm.) Lind., *D.*, *H.*
Tilachlidium tomentosum (Schrad.) Lind., *W.*
Isaria farinosa Fr., *D.*

MYCETOZOA GATHERED DURING THE HEREFORD FORAY.

By G. Lister, F.L.S.

FINE weather prevailed during the five days of the Foray. On Monday, September 27th, Mr St John Marriott collected alone in woods near Dinedor Camp, and found five species; amongst them was *Trichia verrucosa*, which is not often met with. On September 28th the party visited Wormesley Woods in the morning and Credenhill in the afternoon. The chief feature in the Wormesley Woods was a chain of partly dry ponds bordered by oaks; on the branches and twigs which had fallen and lay half-buried in mud and dead leaves by the water's edge were large growths of *Oligonema nitens*, the minute sporangia being heaped together to form conspicuous clusters. Such half-submerged wood is a well-known habitat for this species. On Credenhill some old coniferous stumps under ash and oak yielded *Cribaria argillacea* and *Tubifera ferruginosa*. On September 29th we visited Dinmore Woods, consisting chiefly of tall oaks with an undergrowth of bramble, on high ground; fifteen species of Mycetozoa were found, of which *Fuligo muscorum*, *Diderma floriforme* and a large development of *Stemonitis herbatica* were the most noteworthy. On September 30th we drove to Moccas Old Park; under some of the great oaks and beeches on the grassy slopes of the park, were lying, half-hidden among bracken, huge decaying oak trunks abounding with Mycetozoa; thirteen species occurred on one trunk alone, among them being *Lycogala conicum*, a new record for the British Isles. This species is nearly allied to the very frequent *L. epidendrum* but may be recognised in the field by the neat conical shape of the aethalia and the dark-veined cortex.

In the accompanying list of the forty-one species found during the Foray the localities are indicated by the following initials: *DC.* stands for Dinedor Camp; *W.* for Wormesley Woods; *C.* for Credenhill; *D.* for Dinmore Woods; *M.* for Moccas Old Park; *H.* for Holme Lacy, visited on Friday's expedition.

Ceratiomyxa fruticulosa (Müll.) Macbr., *DC.*, *M.*
Physarum nutans Pers., *W.*, *M.*, *H.*; subsp. leucophaeum Lister, *W.*; P. viride Pers., *M.*, *H.*; var. aurantium Lister, *D.*
Fuligo septica Gmel., *W.*, *H.*; var. candida R.E.Fries, *M.*; F. muscorum Alb. & Schw., *D.*
Craterium minutum (Leers) Fr., *DC.*, *W.*
Diderma floriforme Pers., *D.*
Didymium difforme (Pers.) Duby, *W.*, *M.*, *H.*; D. squamulosum (Alb. & Schw.) Fr., *DC.*; D. Clavus (Alb. & Schw.) Rabenh., *DC.*
Mucilago spongiosa (Leyss.) Morg., *M.*
Stemonitis fusca Roth, *W.*, *D.*, *M.*, *H.*; var. confluens Lister, *M.*; S. herbatica Peck, *D.*; S. ferruginea Ehrenb., *W.*, *D.*

Comatricha nigra (Pers.) Schroet., *D.*, *M.*; C. laxa Rost., *M.*; C. elegans Rost., *M.*; C. typhoides (Bull.) Rost., *W.*, *M.*, *H.*
Enerthenema papillatum (Pers.) Rost., *M.*
Cribraria argillacea Pers., *C.*, *M.*, *H.*; C. vulgaris Schrad., *M.*; var. aurantiaca Pers., *M.*
Dictydium cancellatum (Batsch) Macbr., *C.*, *M.*; var. fuscum Lister, *M.*
Tubifera ferruginosa Gmel., *C.*, *M.*
Reticularia Lycoperdon Bull., *D.*
Lycogala epidendrum (L.) Pers., *W.*; L. conicum Pers., *M.*
Trichia affinis de Bary, *M.*; T. persimilis Karst., *W.*, *D.*, *M.*; T. verrucosa Berk., *DC.*; T. scabra Rost., *W.*, *M.*; T. varia Pers., *M.*; T. Botrytis Pers., *W.*; T. decipiens Pers., *W.*, *D.*, *M.*, *H.*
Oligonema nitens (Lib.) Rost., *W.*
Hemitrichia clavata (Pers.) Rost., *W.*; H. Vesparium (Batsch) Macbr., *M.*
Arcyria cinerea Pers., *W.*, *D.*, *M.*; A. pomiformis (Leers) Rost., *M.*, *H.*
A. denudata (L.) Wettst., *W.*, *D.*, *M.*, *H.*; A. incarnata Pers., *W.*, *D.*; var. fulgens Lister, *M.*; A. nutans (Bull.) Grev., *W.*, *D.*, *M.*

LICHENS OF THE HEREFORD FORAY.

By Robert Paulson, F.L.S., F.R.M.S.

The ground covered by the Foray included a considerable acreage of woodlands situated to the north, west and south-east of our headquarters in the town and at distances of eight to twelve miles away.

These woods vary widely in character; some at Dinmore (to the north) consist of closely growing trees, for the most part young oak, while others contain trees of great age as the magnificent beeches in the wood around the camp on Credenhill and the veteran oaks, which number their ages in centuries, of the woodlands of Moccas Old Park.

It was one of the great pleasures of the Foray to be free to wander and collect in an ancient woodland which contains such notable trees as the "Hut Oak" and the "Tall Oak" of Moccas, monarchs that have attained a height of 94 ft. and 118 ft. respectively.

Woods of young oak yielded little or no lichen material, but the veterans of the Park were mostly covered with species of *Parmelia, Ramalina, Physcia* and *Pertusaria.*

An old fence which stretches for a considerable distance along one side of Moccas Old Park well repaid the close scrutiny that was devoted to it. On the west side of the palings was an abundance of *Bilimbia caradocensis* (studded with numerous apothecia), *Cyphelium inquinans*, *Usnea florida* var. *hirta* and *Physcia hispida.*

The excursion to Mordiford by way of Fownhope covered part of Haugh Wood, Ethelbert's Camp, and included a detour to Holme Lacy. In this locality the outcrop of Silurian Lime-

stone added a few calcareous lichens not seen on the previous days. Perhaps the most frequently noted of these was *Biatorella pruinosa*. On the mortar of an old wall near Fownhope the variety *B. albocincta* occurred.

Other saxicolous species were found upon broken portions of Old Red Sandstone by the sides of ancient cart-ruts, near Wormesley, and on the walls of the disused observation tower on the high ground at Dinmore, where *Acarospora veronensis*, *Lecidea latypea* and *L. goniophila* occurred.

A terricolous species of *Leptogium* collected from a moderately light clay loam of the heathland, Dinmore, agrees very closely with the original description of *Collema cataclystum* Koerb. = *Leptogium cataclystum* Nyl. Its dark olivaceous-fuscous thallus is adnate, laciniate-lobate and crenate. The narrow laciniae occasionally broaden and become wedge-shaped and even hooded. When dry the thallus is hard, but when moistened it becomes decidedly turgid.

It has not been possible to compare this lichen with a type specimen of *Leptogium cataclystum*, but in three Hungarian specimens, from two different localities, we note it can be inferred that the colour, the degree of segmentation and the attachment of the thallus to the substratum, vary within considerable limits.

The home specimen is more closely adnate to the substratum, is darker in colour and more finely laciniate than those from Hungary, and there is in the foreign specimens a nearer approach to the moniliform arrangement of gonimia than is the case in the Hereford lichen.

It is in repect of the spores that the Hungarian and the British species so closely agree. In both they are elliptical-ovate in shape, clearly blunt at one end, frail in appearance, 22–30 μ long, 8–12 μ wide and the muriform cells which number 8–10 are often ill defined. The arrangement of the elliptical spores, end to end, in a chain within a cylindrical-clavate ascus is a striking feature of these lichens.

It is more particularly upon the spore characters that I have included *Leptogium cataclystum pro tem.* in the list of lichens of the Hereford Foray.

The most interesting lichen collected on this occasion is one from Fownhope, described below.

Bilimbia sublubens n. sp.

Thallus effusus, sat tenuis, subareolato-granulosus, obscuro-virescens, K—, CaCl—. Apothecia parva, diam. 0·5–1·0 mm., adnata, planiuscula, margine leviter elevato cincta; hypothecium subincoloratum; paraphyses paucae, facile liberae,

ad apicem plus minus nigricanti-smaragdulae v. sordide olivascentes, flexuosae, ramosae, graciles. Asci clavati 90–110 μ × 16–18 μ, sporae 7–9 septatae, subfusiformes, elongatae, rectae, v. leviter curvulae, 35–48 μ × 7 μ. I. vinose rubet.

This lichen was growing among others on the upper side of the middle bar of an ordinary farm five-barred gate. It was open to the full light of the sun but exposed to clouds of dust from a high road.

It clearly belongs to *Bilimbia* (Lecideaceae) and to the *B. sabuletorum* group. It approaches *B. Nitschkeana* Lahm. in the granulose, greyish thallus, the colourless hypothecium, and the scanty, flexuous, branched, discrete paraphyses. On the other hand, it resembles *B. lubens* A.L.Sm. in the septation (5–9 septa) and in the large size of the spores, which measure 28–50 μ long and 7–11 μ thick.

The letters placed after the names of the species and varieties indicate the localities in which the lichens were collected, viz. *W.* = Wormesley and Credenhill, *D.* = Dinmore, *M.* = Moccas Old Park, *H.* = Haugh Wood, *E.* = Ethelbert's Camp, and *F.* = Fownhope.

The list includes ninety-eight species and varieties. *Bilimbia sublubens* n.sp., and *Leptogium cataclystum* are new to Great Britain and *Biatorella pruinosa* var. *albocincta* is recorded as of rare occurrence; it is possible that it may have been overlooked.

I am much indebted to Miss A. Lorrain Smith for the help she has given respecting the determination of critical species, and to Mr H. H. Knight for placing his lists, with notes, at my disposal.

CALICIACEAE.

Chaenotheca melanophaea Zwackh., *W.*, *D.*
Calicium hyperellum Ach., *M.*, *W.*, *D.*
Cyphelium inquinans Trev., *D.*, *M.*, *E.*

COLLEMACEAE.

Collema pulposum Ach., *D.*
C. tenax Sm., *H.*
C. multifidum Schaer., *D.*
Leptogium cataclystum Koerb., *D.*

PELTIGERACEAE.

Peltigera canina Willd., *W.*, *M.*

PARMELIACEAE.

Parmelia physodes Ach., *D.*, *W.*
P. caperata Ach., *M.*
P. saxatilis Ach., *W.*, *D.*, *M.*
P. saxatilis f. furfuracea Schaer., *M.*
P. sulcata Tayl., *W.*, *M.*
P. dubia Tayl., *W.*, *D.*
P. fuliginosa Nyl. var. laetevirens Nyl., *W.*, *D.*, *M.*

USNEACEAE.

Evernia prunastri Ach., *W.*, *D.*, *M.*
Ramalina calicaris Fr., *W.*, *M.*
R. fastigiata Ach., *M.*
R. farinacea Ach., *M.*
Usnea florida Web., *W.*
U. florida var. hirta Ach., *W.*, *M.*

PHYSCIACEAE.

Xanthoria parietina Th. Fr., *W.*, *M.*
Placodium murorum DC., *E.*
P. citrinum Hepp, *W.*, *D.*
P. aurantiacum Anzi var. flavovirescens Hepp., *E.*
P. pyraceum Anzi, *D.*
P. rupestre Branth. & Rostr., *H.*, *F.*
Candelariella vitellina Müll.-Arg., *W.*, *D.*
Physcia ciliaris DC., *W.*
P. pulverulenta Nyl., *M.*
P. stellaris Nyl. var. cercidia Th.Fr., *M.*
P. hispida Tuckerm., *W.*, *F.*

P. erosa Leight., *M.*
P. caesia Nyl., *W.*, *M.*
Rinodina sophodes Th.Fr., *M.*
R. exigua S.F.Gray, *W.*, *M.*, *F.*
R. demissa Arn., *W.*, *D.*, *H.*

LECANORACEAE.

Lecanora muralis Schaer., *F.*
L. subfusca Nyl. var. allophana Ach. *W.*, *D.*
L. rugosa Nyl., *W.*
L. campestris D.de Lesd., *D.*, *F.*
L. atra Ach., *D.*, *M.*
L. Hageni Ach., *W.*, *F.*
L. galactina Ach., *H.*, *F.*
L. varia Ach., *W.*, *D.*, *M.*
L. symmicta Ach., *W.*, *D.*
L. symmictera Nyl., *M.*
L. parella Ach., *H.*, *S.*
Acarospora veronensis Massal., *D.*
Lecania albariella A.L.Sm., *M.*

PERTUSARIACEAE.

Pertusaria faginea Leight., *W.*, *M.*
P. pertusa Dalla Torre & Sarnth., *W.*, *M.*
P. leioplaca Schaer., *D.*
P. Wulfenii DC., *M.*

THELOTREMACEAE.

Phlyctis agelaea Koerb., *W.*

CLADONIACEAE.

Baeomyces rufus DC., *W.*
Cladonia sylvatica Hoffm., *D.*
C. pyxidata Hoffm., *D.*
C. fimbriata Fr., *W.*, *D.*
C. furcata Schrad., *W.*
C. macilenta Hoffm., *D.*

LECIDEACEAE.

Lecidea ostreata Schaer., *D.*, *M.*
L. quernea Ach., *M.*
L. coarctata Nyl., *W.*, *D.*
L. mutabilis Fée, *F.*
L. fuscorubens Nyl., *H.*
L. parasema Ach., *W.*
L. latypea Ach., *D.*
L. goniophila Schaer., *D.*
L. crustulata Koerb., *W.*
Biatorella pruinosa Mudd, *H.*, *F.*
B. pruinosa f. nuda A.L.Sm., *F.*
B. pruinosa var. albocincta A.L.Sm., *F.*
Biatorina Griffithii Massal., *M.*
Bilimbia caradocensis A.L.Sm., *M.*
B. sublubens nov. sp., *F.*
Buellia canescens de Not., *M.*
B. myriocarpa Mudd, *W.*
Leciographa parasitica Massal., *M.*
Rhizocarpon alboatrum Th.Fr., *W.*, *M.*
R. alboatrum var. epipolium A.L.Sm., *W.*
R. petraeum Massal., *H.*, *E.*
R. obscuratum Massal., *W.*

ARTHONIACEAE.

Arthonia radiata Ach. var. Swartziana Syd., *W.*

GRAPHIDIACEAE.

Opegrapha herpetica Ach., *M.*
O. atra Pers., *M.*
O. atra var. denigrata Schaer., *M.*
O. betulina Sm., *H.*
O. saxicola Ach., D.
O. vulgata Ach., *H.*
Graphis elegans Ach., *W.*

VERRUCARIACEAE.

Verrucaria aethiobola Wahlenb. var. acrotella A.L.Sm., *D.*
V. papillosa Ach., *H.*
V. viridula Ach., *F.*
V. nigrescens Pers., *W.*, *M.*
V. glaucina Ach., *F.*
V. muralis Ach., *H.*
V. integra Carroll, *F.*

PYRENULACEAE.

Arthopyrenia fallax Arn., *W.*, *D.*
A. submicans Arn., *W.*

PRESIDENTIAL ADDRESS.

By George H. Pethybridge.

MYCOLOGY AND PLANT PATHOLOGY.

The British Mycological Society was founded on September 19th, 1896, so that our present Foray falls near its thirtieth birthday. The Woolhope Naturalists' Field Club, in happy conjunction with which this meeting is being held, had, for some quarter of a century before the birth of our Society, been conspicuous for the success of its fungus forays, and our activities may be looked upon to some extent as a continuation and expansion of those of that club. My own connection with the Society has been but a slender one. Having till recently been resident out of England for over twenty years, I have not been able to enjoy to the full the privileges of membership. However, I now find myself in the exalted position of President, an honour which involves the delivery of a presidential address.

I cannot deal in detail with the Society's history during the past thirty years, or review the progress of mycology the world over and assess exactly the part that the Society has played in the advance of our knowledge of fungi during that period. My own career has been more that of a botanical "maid-of-all-work" than that of a mycologist, and thus I possess inadequate qualifications for such a task. This is the less to be regretted, however, since one of our past Presidents, Mr Carleton Rea, covered this ground in his address in 1922.

In casting about for a peg on which to hang a few remarks appropriate to the present occasion, the motto of the Society "Recognosce notum, ignotum inspice," which I read as meaning "Nod to the known, study the strange," suggested itself.

Now Nature is never at a standstill, change and development are always in progress; evolution still proceeds, consequently the number of the "ignotum" can never be an absolutely finite quantity. Nevertheless, since the birth of new species is relatively a slow process, the "ignotum"—provided that the hunt continues—must steadily diminish and the "notum" constantly increase.

In proof of this I need but recall, so far as this country is concerned, such events as the publication in 1913 of W. B. Grove's volume on the *British Rust Fungi*, and of Carleton Rea's *British Basidiomycetae* in 1922. Further, there are Miss Lorrain Smith's Monograph of *British Lichens* and Miss Lister's on the *Mycetozoa*, both of which in revised or completed form have appeared during the current year. Reference might also be

made to Mr Ramsbottom's *List of British Discomycetes* published some years ago, and to other lists and notes published during recent years.

The "ignotum," therefore, is rapidly diminishing, and must eventually disappear almost entirely. There will, of course, always be individuals to whom the "ignotum" will be large, and to such the prosecution of the Society's work along its present main lines will always be of the utmost value; but are there not other paths that might perhaps be followed with advantage?

Let us see how the pursuit of our motto works out in actual practice, assuming that our Forays constitute the most important part of our activities; they are certainly the oldest. We select special localities and are guided almost entirely by the availability of woodland areas in the district chosen. In such surroundings we expect to find an abundant mycological flora, especially of the higher forms. We list those we know at sight, we examine in detail the less well known, and, after identification, add them to the list. The longer the list the happier we are.

Now, I would not underestimate the joy of recognising old fungus friends, and of making new ones. Nor must one forget the chances of recording species hitherto not found here, or of discovering others new to science.

But the making of mere inventories—important in their way as they are—must at some time come to an end; and the question is whether the time is not at hand when we may feel satisfied that our British fungal census is reasonably complete. If that be so, should not some of our energies be diverted into other channels?

The phanerogamic flora of the British Isles is now pretty thoroughly known. The distribution of the various species has been worked out in considerable detail. The proportion of "notum" to "ignotum" is very large indeed. But the study of flowering plants in the field has not come to a halt; it has taken a new direction. Instead of merely recording the presence or absence of species in political areas such as counties, provinces or kingdoms, those living in consort within naturally defined habitats have been grouped, the conditions prevailing in such habitats studied and the relationships of the plants to their environment examined.

This is study on ecological lines, and it leads ultimately to an examination of the bionomics of each species, involving in some cases even that of the individual itself. Something of this kind has already been begun amongst fungi, as the recently published and intriguing work of Professor A. H. R. Buller testifies. His three lengthy but stimulating volumes of *Researches on Fungi*

bristle with new and ingenious ideas, and reveal many aspects of mycology which have hitherto claimed all too little attention.

Botanists everywhere have been busy in recent years in the study of vegetation, but to what extent has the position occupied by cryptogams in the scheme of affairs been studied? To a relatively very small extent; and the mycological aspects have been almost entirely neglected. In that pioneer book, *Types of British Vegetation*, published some years ago, the word *fungus* does not occur in the general index, nor does the name of any fungus occur in the index of plant names. In the preface it is stated, "the lower plants generally are, for the most part, mainly through want of knowledge, very inadequately treated, and in the case of many plant communities, ignored altogether. This is greatly to be regretted, since these plants are frequently of the first importance in differentiating plant communities."

Here, then, there would appear to be considerable scope for mycological survey and endeavour. In some respects the work would not at first differ essentially from that hitherto accomplished; for lists of the genera and species of fungi accompanying the other members of the plant communities would have to be prepared. It is possible that preliminary lists could be compiled now from existing data, without additional field work; but for the study of the relationships of the fungi to the remainder of the flora in the association and to the other factors of their environment, further field work is essential, and it would probably have to be supplemented by work in the laboratory.

The fact that fungi are saprophytic or parasitic, and are specialised in regard to the substrata on which they flourish would render such a study all the more fascinating, although certainly not less difficult. Moreover, such studies would have to reckon not only with those forms with conspicuous fructifications, but also with those involving the use of the microscope for their elucidation. Finally, the examination of the associations from the mycological point of view would have to be frequent and more or less continuous, otherwise some forms might escape attention altogether, since fungi, on the whole, are much more evanescent in their appearances than most of the higher plants.

The idea of arranging fungus forays to salt marshes, sand dunes, bogs, heaths, moors, arctic-alpine mountain-tops and other such places, instead of confining them more or less to associations of the woodland type may perhaps appear to be a preposterous one. The bag would be too small, the lists too attenuated and in general "the game not worth the candle"! Nevertheless, there can be no question but that the study of fungi from their ecological and bionomic aspects offers great

possibilities, and is a field which has hitherto been relatively neglected*.

I turn now from this important side of the Society's activities to a more specialised and technical one, namely, plant pathology. If we try to trace the development of this subject in this country we shall find that at one time mycology was regarded as of little or no importance in relation to the causation of plant diseases. In the earlier days of Berkeley, who may be regarded perhaps as the founder of phytopathology in this country, the idea that plant diseases were caused by fungi was by no means widely accepted. On the contrary, any fungi which might occur in connection with disease were regarded as the *result* of such disease, not the cause of it. Thus, when the potato blight first appeared here in the 'forties of last century, a very considerable and important band of scientific men vigorously opposed the idea that the blight could be caused by a fungus. Berkeley, however, was one of a small minority of men of real insight, who shared his opinion when he maintained (*Journ. Hort. Soc. Lond.* 1 (1846), p. 23) that "the decay is the consequence of the presence of the mould, and not the mould of the decay"—a view which subsequently proved to be correct.

This was in 1846. By 1860 matters had progressed considerably and Berkeley then wrote: "Fungi were long regarded as the mere creatures of putrescence, and therefore as the consequence, not the cause of disease. A more intimate acquaintance with their structure and habits has, however, removed much of this prejudice, and almost everyone is now ready to acknowledge what a weighty influence they have in inducing diseased condition, both in the animal and vegetable world." Such are the opening sentences of Chapter X of Berkeley's *Outlines of British Fungology*, and a perusal of this chapter at the present day enables one to realise something of the extent to which plant pathology has advanced during the past half-century or so. So far as bacteria are concerned, however, it was not till 1901 that the possibility of their being capable of causing disease in plants was eventually conceded on all sides. To-day the pendulum has swung far in the other direction; in the opinion of some, perhaps too far; because ever-increasing attention has been paid to the parasite as the cause of disease, whilst other factors have tended to suffer somewhat from neglect.

Disease in plants is the result of disharmony between the plant and its environment. A parasite, of course, if present, is part of the plant's environment considered in its widest sense.

* Since the above was written, an article on the Ecology of Fungi by J. Ramsbottom has appeared in the *Aims and Methods in the Study of Vegetation*, the handbook of the British Empire Vegetation Committee.

But if we treat it as a separate or special factor, we then get the eternal triangle, host, parasite and environment. Nor must it be forgotten that both host and parasite are to some extent variable or unstable, and that the fluctuating factors of the environment may influence the parasite as well as the host.

In spite of this complexity, however, it is still true that the parasite is often the most important factor in disease production; hence the intimate connection between mycology and plant pathology remains, a connection well brought out by Mr F. T. Brooks in his Presidential Address delivered at the Keswick Autumn Foray in 1922. So close is the relationship between the two that, in this country at any rate, plant pathologists are often—and some of them, indeed, officially—called mycologists. This, however, is somewhat of a misnomer; for it will be evident that a plant pathologist must be something other than a pure mycologist, if he is to be worthy of his name and profession.

A mistake frequently made is to confuse the name of a disease with the name of the parasite, confusing, that is, practically, effect with cause. The most recent example of this lack of discrimination that I have seen occurs in a publication issued by the United States of America Federal Horticultural Board entitled *Foreign Plant Diseases*. This bulletin consists essentially of a list of, perhaps, 10,000 names of presumably parasitic fungi, bacteria and eelworms, arranged according to hosts, and covering one hundred and ninety-six closely-printed pages. The parasites mentioned are said either not to occur or not to be widely distributed in the U.S.A. It is certainly not a list of plant diseases. It may perhaps frighten some persons to think of the enormous number of plant diseases that might develop in their midst, but to pathologists such a list appears much less formidable, especially when regard is paid to the fact that host, parasite *and* environmental conditions all play a part in the production of disease.

That the physical factors of the environment are often of considerable and in some cases of paramount importance in the inception and spread of disease in plants, plant pathologists and growers of plants know well. For instance, in the absence of certain conditions of atmospheric moisture and temperature, even in the presence of the respective parasites, the "damping off" disease of seedlings, due to *Pythium*, does not occur; *Botrytis* does little or no harm in the glass house; potato blight may not appear at all, or, if it does, may not become epidemic; celery leaf spot remains practically harmless; beans remain free from Chocolate Spot disease, and so on. Briton-Jones has recently brought forward evidence to show that the Die-back of fruit trees is probably the result of preliminary enfeeblement

due either to excessive or to insufficient soil moisture and followed by weak parasites, such as *Diaporthe* and *Cytospora*, rather than the consequence of primary virulent parasitism.

Again, physical climatic factors—temperature for instance—sometimes play a decisive part in determining whether a specific disease may or may not prevail in a particular region. The spores of *Urocystis Cepulae*, the fungus which causes Onion Smut, do not germinate readily above 25° C. and not at all above 29° C. Hence this disease is of little or no importance in hot climates, and is confined to cooler ones. Species of *Fusarium* and *Verticillium* which cause wilts of potatoes, tomatoes, flax, etc., differ in their temperature relations. Thus, Flax Wilt, due to *F. Lini*, is a very serious disease in parts of the United States of America. In the North of Ireland, however, although the fungus is present there, the disease is practically negligible, owing to the relatively cooler summers. *Verticillium* Wilt of the potato is a disease of relatively cool climates and is met with to some extent in this country, whereas the *Fusarium* Wilt, depending on a higher temperature, is, so far as I am aware, unknown in this country, although it occurs in Central Europe and in the warmer parts of America.

Climatic and weather conditions cannot yet, of course, be regulated by man, although attempts to modify their influence have not been entirely wanting. When, however, plants are grown under glass it is possible, to a considerable extent, to control soil and atmospheric temperature and humidity as well as light intensity; and the most successful grower is he who can so control these conditions as to avoid disease and get a maximum crop. Here the scope for pathological research is wide, because there is still a great lack of exact scientific knowledge as to the precise conditions which favour or impede the onset of the various diseases of glass-house crops.

In recent years a good deal of experimental work has been done in connection with the artificial enrichment with carbon dioxide of the atmosphere in which plants are growing; furthermore, the study of the effect of electricity on crops has been fairly intensively pursued of late. True, investigations on these lines have been proceeding mainly—if not entirely—from the point of view of crop yield; nevertheless, it is not impossible that environmental factors of these kinds may have some connection with the problems of disease, and plant pathologists should therefore not lose sight of them.

With regard to chemical factors, there is a much wider scope for intervention, for the manuring of a crop may be varied almost to any extent. We know, for instance, that excessive nitrogenous manuring disposes cereals to rusts, turnips and

swedes to bacterial rot and, in general, seems to undermine the power of plants to resist the attacks of parasites. Similarly, lack of potash may dispose towards parasitic disease, as for instance, rust in mangolds and beet. On the other hand, lack of this element may also lead to disease in which parasites are not concerned, as recent research is tending to show with leaf-scorch of fruit trees, although here other factors may perhaps also be concerned. Lime, or the soil alkalinity produced by it, may be the chief factor in inducing the parasites which cause ordinary and powdery scabs respectively to assert themselves and attack potato tubers. On the other hand, through its agency crucifers may be grown free from Finger-and-Toe disease; not because it is directly lethal to the parasite—for recent research has shown that this is probably not the case—but for some other reason not as yet fully understood.

Although an enormous amount of work has been done on soils and manuring from the chemical point of view, very little of it has had any special bearing on plant pathology. It has often struck me that there is a field of work here for the pathologist well worthy of closer attention and one which might yield important and far-reaching results.

Some ten or fifteen years ago a considerable amount of attention was being devoted to the study of the effect of dosing crops with relatively minute quantities of certain chemical substances (*not* the old salts of K, N, P) which appeared to act in some way as a decided stimulus to growth and development. If I remember rightly, a good deal of work of this kind was done in Japan with the rice crop. But the alleged stimulating action of such substances was also studied to some extent in this country; for I recollect seeing pot experiments at Woburn in this connection in or about 1912. One series of pots containing wheat struck me very forcibly, in which the stimulating substance was a salt of lithium. As is well known to all who have attempted to grow cereals under glass, it is almost impossible to avoid the development of the common mildew, *Erysiphe graminis*, on the young experimental plants. The cultures at Woburn were no exception in this respect; but the remarkable thing was that the plants in certain pots, watered with a very dilute solution (in the region of 1–3 in 100,000) of a salt of lithium remained free from mildew. So far as I am aware this matter has never been fully followed up, although it seems well worth doing from the pathological point of view and some attention was devoted to it in 1913 by G. T. Spinks (*Journ. Ag. Science*, v (1913), 231).

That the presence or absence of the compounds of certain chemical elements may have a profound influence on the plant is of course well known, but the elements that have been

thoroughly tested in this respect are all too few, and that there is much more to be learned is evidenced by the recent work of Miss Brenchley with boron. In this connection reference may be made to some experiments conducted at Kew more than twenty years ago by G. Massee (*Journ. Roy. Hort. Soc.* XXVIII (1903), 142). It was found that by watering tomato and cucumber plants at regular intervals, with a dilute solution of copper sulphate (1 in 7000) they could be rendered immune from attack by both *Cladosporium fulvum* and *Dendryphium comosum*. The experimental plants were fully exposed to infection, since they surrounded affected plants, and, moreover, they were sprayed with spore-suspensions of the parasites. They remained healthy, however, whilst checks similarly treated but not watered with the copper sulphate solution became badly diseased. The results were explained by saying that "the copper arrests or modifies the production of some substance in the leaves, which favours the entry of the fungus into the plant." Work on somewhat similar lines has been done by E. Marchal in connection with the *Bremia* disease of lettuces, and also by Pichi, Rumm, Viala, Laurent and Hall with other hosts and parasites. In some cases, it is true, the results were not encouraging, but the chemical substances tried were nearly always salts of copper, and the subject cannot be looked upon as at all exhaustively studied. Further work with compounds of other elements might give quite different results; and to me, at any rate, the idea of inducing immunity or resistance in plants by chemical means is an attractive one and worthy of being followed further.

Of course, the factors of a plant's environment, apart altogether from the presence of any parasite, may have a profound effect on the plant itself, and disease may be the direct result of unsuitable environmental conditions. Such diseases—sometimes not very happily referred to as "physiological diseases"—are also the concern of the plant pathologist. But even here care is required or serious errors may be made. Take for example the disease of fruit and other trees known as Silver Leaf. It is characterised by a silvery or leaden sheen in the foliage. Branches die back and often, but not always, the whole tree becomes killed. In former days—as now—in spite of much search, no parasite of any kind could be found in the affected leaves, hence the disease was placed by various English, French and German writers in the non-parasitic category.

Thanks to the work of Percival, Brooks and others in this country, however, we now know with certainty that Silver Leaf is a parasitic disease due to the attacks of *Stereum purpureum*. We know that this fungus gains entry through wounds; we know at what time of the year infection most readily occurs,

and we also know that, just as "love laughs at locksmiths," so *Stereum purpureum* is not prevented from entering a wound by a covering of tar. Other important information has also been discovered concerning this fungus and its host relationships, such as the development of a "gum" barrier which occludes the parasite, and so on. I need not recapitulate the details, but may merely point the moral that here is a disease which for long passed as a non-parasitic one and for which no remedy based on accurate knowledge could be suggested. But with the discovery of its parasitic nature and a knowledge of the behaviour of the parasite itself, we are now in a much better position to deal with the disease than formerly; and proportionately as our understanding of the enemy and his habits is increased by further research, so our power of checkmating him will develop.

After this considerable digression, let me now return to the path of tracing the development of plant pathology in this country. In addition to Berkeley, some of the other mycologists and botanists, whose names will always be remembered in connection with the rise and development of British phytopathology, are M. C. Cooke, C. B. Plowright, Worthington G. Smith and George Massee. The name of Harry Marshall Ward occupies perhaps a special place, for his more important work differed considerably from that of most previous and even contemporaneous workers, in that it was not concerned so much with descriptive accounts of parasites and symptoms of disease as with *experimental investigations* on the disease-producing fungi and their hosts, carried out under controlled conditions. His studies in parasitism have been said to have laid the foundations for all later investigations into the nature of susceptibility and immunity in plants; and his death twenty years ago, at the comparatively early age of fifty-two, was an irreparable loss. His influence, however, still lives and continues to bear fruit.

The further development of plant pathology in this country has been, until recently, comparatively slow, more so, indeed, than in some foreign countries. This may perhaps be accounted for partly by the fact that as compared with the development of our great manufacturing industries, that of agriculture has been to a great extent neglected. But even in industrial matters Britain has been almost notoriously behind-hand, as compared with other progressive nations, in the application of science and scientific methods. A general apathy towards science, a positive dislike to it in some quarters, our habit of "muddling through" our difficulties somehow and of stupidly being proud of doing so, have been characteristic of this country in the past; and much has even yet to be done to enlighten, not only the man in the street, but also some of those in high authority, of the rightful

place of science in our national life. The recent war opened our eyes to the many dangers of the neglect of science, and it is to be hoped that the lessons then learned will not soon be forgotten.

During the latter half of the nineteenth century the importance of plant pests and diseases became increasingly recognised. In 1877 the possibility of the introduction into this country of the destructive Colorado potato beetle caused such alarm that our first Act of Parliament dealing with the protection of crops was passed, although no special service was inaugurated for the purposes of the Act. Again, the occurrence in 1900 for the first time in this country of the American Gooseberry Mildew, and its rapid and destructive spread throughout the land during the following few years was undoubtedly one of the main causes which led, in 1907, to the passing of the Destructive Insects and Pests Act, which amplified and extended that passed thirty years previously. Moreover, in connection with the 1907 Act a small *ad hoc* inspectorate was inaugurated by the then Board of Agriculture, which has since grown to considerable proportions. Some six years later the Board for the first time appointed an economic entomologist to their own staff, and not long afterwards added a mycologist, thus laying the foundations of the Ministry's present Plant Pathological Laboratory. The Scottish Board added a plant pathologist to the staff of the Royal Botanic Garden, Edinburgh, in 1924, and the Forestry Commission has recently appointed a mycologist. Pathological work in connection with fruit transport and storage is also being carried on now under the auspices of the Department of Scientific and Industrial Research.

An important milestone was reached in 1911, this time in the academic world. This was the foundation at the Imperial College of Science, South Kensington, of a chair in Vegetable Physiology and Pathology, thus indicating an increasing recognition of the importance of the study of plant diseases. Up to the present, unfortunately, this has remained the sole academic chair devoted to plant pathology (apart from its entomological aspects) in this country; but we all rejoiced to learn not long ago that the University of London had conferred the distinction of a professorship on that indefatigable worker Mr E. S. Salmon of Wye College.

The greatest stimulus the development of plant pathology (as well as other branches of agricultural and horticultural science) has received in this country in recent years, however, followed from the provision by the State of greatly increased funds through the Development and Road Improvement Funds Acts, 1909 and 1910, and subsequently through the Corn Production Acts (Repeal) Act of 1921. The importance of developing

research and advisory work in plant pathology, including both diseases and insect pests, was recognised by those charged with the administration of these Acts from the very first; and the present greatly improved position of plant pathology in this country is therefore very largely the result of increased State aid to agriculture, available through the operation of the Development Fund.

For this reason we now have (attached to the Rothamsted Experimental Station) newly erected and lavishly equipped laboratories for unrestricted research in the basic problems of plant pathology. We have plant-disease research work associated with the Universities of Bristol, Cambridge and Wales, as well as with the Experiment Stations for glass-house crops and fruit-growing at Cheshunt and East Malling respectively. This work is carried on by permanent members of the staffs of the institutions in question, by workers provided through the agency of special research grants, or by research scholars. Other phytopathological activities supported by State aid are the Ormskirk Station of the National Institute of Agricultural Botany for the testing of potato varieties for immunity from wart disease, and the Official Seed Testing Station in Cambridge, at which a beginning has recently been made in supplying farmers with information concerning the presence or absence of parasitic fungi on certain kinds of seeds.

In connection with the scheme of increased State aid to agriculture, England and Wales have been divided into fourteen provinces, and in each province, in addition to other advisers, two (a mycologist and an entomologist), have been attached to the staff of the University or College, the Agricultural Department of which is the recognised centre for the province. These officers provide advice for the farmer in their respective subjects, engage in investigations on local phytopathological problems and together form a nucleus for plant-disease and pest survey and intelligence work, the headquarters of which are at the Ministry's Plant Pathological Laboratory in Harpenden.

It is important, however, to note that these developments have not been due solely to State aid, for in some of the cases mentioned this aid has merely been supplementary to substantial financial support from those connected with or interested in the agricultural and horticultural industries. Phytopathological work is also carried on to some extent (unaided by the State) in other ways and at other centres, as for instance at the John Innes Horticultural Institution and at the Wisley gardens of the Royal Horticultural Society, to say nothing of the educational and research work carried on as a normal part of the programmes of some of our Universities and Colleges.

Mention must also be made of the Imperial Bureau of Mycology, founded a few years ago. Although instituted primarily to assist in the development of plant pathology in our Dominions and Colonies and financed entirely by them, this Bureau, directed by our present Vice-President, is also of great service to workers in the Mother Country, both through the excellent monthly abstracts which it publishes and in other ways known to many of you. Nor must the cryptogamic departments of the British Museum and the Royal Botanic Gardens, Kew, be left out of account. For, although their work is perhaps generally regarded as being of a more purely systematic nature, the mycologists there, as we pathologists know well from experience, are frequently a very present help in time of trouble.

Our own Society, also, is by no means forgetful of the assistance which it can render to plant pathology. Its sub-committee has in an advanced state of preparation a standardised list of the common names appropriate for the principal diseases of plants in this country, the publication and adoption of which will, it is hoped, result in the simplification of and uniformity in such nomenclature. Further, much of the time at the winter meetings of the Society is devoted to the reading of papers on, and the discussion of, plant pathological matters, whilst the Society's *Transactions* bear witness to its interest in the subject also. Lastly, the Association of Economic Biologists, both by its meetings and by the publication of papers in its *Annals*, has to an ever-increasing extent in recent years helped to advance plant pathology in this country.

This brief sketch will perhaps enable us to realise something of the position in which plant pathology stands to-day in this country. From it will be gathered, I hope, the main features of present-day *organisation* for the study and practice of plant pathology here; it will show the *machinery* we at present possess for the work. Undoubtedly it represents a very great advance on the facilities, or lack of facilities, which prevailed but comparatively few years ago, although there may be some who, comparing the position here with that in some foreign countries, may still be dissatisfied. High ideals must always carry with them a certain degree of divine discontent. The machinery must be judged by its output or by the work it fails to accomplish. It has been set in motion too recently for us to decide yet whether it is satisfactorily fulfilling its purpose or not. Judged by the numerous papers which have appeared in our various scientific and technical periodicals during the last few years, there is considerable cause for satisfaction, and those of you who would gain some idea of what is being attempted, where State

aid is given, cannot do better than consult the Annual Reports of the Development Commissioners, the last published of which, the sixteenth, covers the year ending March 31st, 1926. Here, of course, will be found not only what is being done in regard to plant diseases, but also what is going on in all the other lines of research and education as applied to agriculture, so that a perspective view of the place of plant pathology amongst the other subjects can be obtained*.

Personally, I am inclined to think the time must come sooner or later when the organisation of plant pathology in this country will require some modification and extension. At present decentralisation appears to be the key to the situation. I, however, should like to see the development, in time, of a strong central institution, not attached as a side-issue to any existing institution, but firmly based on its own foundation and having its own well-defined duties and responsibilities in relation to the agricultural and horticultural industries of this country, with which it would have to maintain intimate contact. At such a centre the staff would comprise not only applied mycologists and entomologists, but also systematists in these subjects. Further, botanists, zoologists, chemists and physicists would contribute their share, to say nothing of physiologists, plant-breeders, bacteriologists and so on. In short, provision should be made, as and when required, for attacking all problems in plant pathology, and these demand for their solution men trained in a considerable number of branches of science. So-called "fundamental" research would not be segregated, for all true research is fundamental. The "applied" lion would have to lie down with the "pure" lamb, or rather the two would waste no time in lying down, but would both be up and doing, the efforts of one supplementing those of the other.

I do not suggest that it is necessarily the duty of the State to provide such an institution, although I am afraid that the industries concerned would find it hard to do so unaided in present circumstances. A private benefactor might do worse than found and endow a Central Institute of Plant Pathology in this country, and such a foundation would ensure the necessary co-operation, concentration and continuity in research and in its practical applications which is not easy of attainment under present conditions. Such a foundation would not necessarily supplant existing agencies, but would rather supplement them.

A feature which may strike an onlooker at the modern developments in plant pathology in this country is that no

* *Research and the Land*, by V. E. Wilkins, published in 1926 by the Ministry of Agriculture and Fisheries subsequent to the delivery of this Address, provides a fuller account.

special effort has been made to train the personnel required, or even to formulate the lines along which training should proceed. Matters have proceeded so rapidly that workers have had to be found in a more or less haphazard way. This was perhaps more or less inevitable at the outset, but there is no reason why the problem, so far as future workers are concerned, should not be tackled.

Mr Brooks, in the Presidential Address to which reference has already been made, offered some suggestions as to the training of mycologists and plant pathologists. With most of his suggestions I am in full agreement, but in one respect I differ from him. He suggests that during the *later* stages of his training the embryo pathologist should be given some familiarity with the growth of crop plants and with crop values. This I admit is better than nothing, but it does not satisfy me. I am convinced that one of the greatest difficulties confronting plant pathology to-day is that much of it is too remote from actual agricultural and horticultural practice. The practitioner does not know nearly enough about his patients, how they grow, what complicated conditions surround the production of crops at a profit, and so on. We are all unfortunately too academic in outlook; and in nine cases out of ten this can never be cured by an attempt to inculcate the right kind of view-point at a late stage of the pathologist's training.

Before a plant pathologist can be trained he must be *recruited*, and in my view he should to a large extent, at any rate, be recruited deliberately from amongst those who understand what agriculture and horticulture really are, because they practise these arts. Select from such sources promising young people with brains, intelligence and zeal. They are as plentiful, proportionately, in these walks of life as in others, but they need careful seeking out. Put them through your more or less academic courses of the various sciences. Their own inherited and acquired instincts will enable them to separate the gold from the dross in these courses, and they will emerge with a knowledge not only of scientific methods, facts and principles, but will be able themselves to determine how best to apply them in actual practice.

It is not, however, my purpose on this occasion to be critical of present arrangements, but rather to show what the existing conditions are in regard to plant pathology in this country, and I return now, in conclusion, to our motto and its application to the plant diseases prevalent here.

For the past nine or ten years a systematic attempt has been made by the pathological department of the Ministry of Agriculture and Fisheries to ascertain exactly what diseases of crops

exist in this country and to what extent their occurrence and intensity vary from year to year. The results of this phytopathological survey have been issued from time to time, the last Report having been published as Miscellaneous Publications No. 52, 1926. It is believed that we now have a fairly complete inventory of the diseases of agricultural and horticultural crops which occur here; the proportion of "notum" to "ignotum"—so far as the existence and names of the diseases are concerned—being therefore very large. In preparing the lists, many members of this Society have rendered valuable service which is greatly appreciated.

But we cannot rest on our oars. We must not remain satisfied with being able merely to diagnose a disease, give it a name and furnish the name of the parasite which causes it—if, as is usually the case, the disease is of a parasitic nature. About many of our diseases—even some of the commonest ones—but little is really known beyond names. If we set as an ideal before ourselves not to be content until we can prevent or cure the various diseases by methods which are not beyond the economic possibilities of practical husbandry, then we shall soon realise how much remains yet to be done. This, after all, and whether we like it or not, is the "acid test" by which our work will be judged by those whom we profess to serve, viz. the growers of crops; and realisation of our present ignorance will, to the keen, enthusiastic worker, act as a stimulant to further effort; only to the indolent will it serve as an excuse for pessimism.

STUDIES IN ENTOMOGENOUS FUNGI.

XIII. GLENOSPORA.

By T. Petch, B.A., B.Sc.

In *Sylloge Fungorum*, IV (1886), 298, Saccardo listed the genus *Glenospora* Berk. & Curt., with the species *Glenospora Curtisii* Berk. & Desm. and *Glenospora ramorum* (Schw.) B. & Br. The descriptions there given are as follows:

"*Glenospora* B. et Curt. North Am. Fungi n. 1002, Sacc. Mich. (Etym. *glene* cavitas v. oculus et *spora*).—Hyphae biogenae, in crustam atram intextae, varie ramosae, septatae. Conidia ramulis diu haerentia, globosa, majuscula, levia.

"*Glenospora Curtisii* Berk. et Desm. North Amer. Fungi n. 1002, Sacc. Mich. II, pag. 147, Fung. ital. tab. 792.—Effusa subcrustacea, aterrima, hispidula; hyphis fertilibus assurgentibus

furcatis v. varie breve ramulosis, parce septatis, fuscis; conidiis perfecte sphaericis 10–12 μ diam., in ramulis subsolitarie acrogenis, guttulatis fuligineo-olivaceis, diu persistentibus. Hab. in cortice subvivo *Magnoliae, Nyssae, Quercus, Cyrillae* etc. in America boreali.

"*Glenospora ramorum* (Schw.) B. et Br. *Rhacodium ramorum* Schw. Carol. n. 1362, *Oedemium ramorum* Fries, Syst. III, p. 345.—Crusta tomentosa tenui 2–3 cm. effusa; hyphis ramosis intricatis diffusis, nigris, tenuibus continuis; fertilibus assurgentibus; conidiis globosis, pedicellatis, minutis, numerosissimis. Hab. in ramulis vivis *Quercuum* et *Andromedae arboreae* in Carolina."

The reference to *Michelia*, II (1880), 147, is to a description of *Glenospora Curtisii* drawn up by Saccardo from specimens on *Magnolia* sent by Ravenel, which is the same as that given in the *Sylloge*. No generic description was included there. The generic description in the *Sylloge* was apparently drawn up by Saccardo later.

The reference to North American Fungi, no. 1002, is to an entry in an instalment of "Notices of North American Fungi" by the Rev. M. J. Berkeley in *Grevillea*, IV (1876), 161, where the genus *Glenospora* and the species *Glenospora Curtisii* were described as follows:

"*Glenospora*. B. & Curt.—Flocci fastigiati fasciculati parce articulati, hic illic sporangia globosa sessilia vel pedicellata ferentibus.

"1002. *Glenospora Curtisii*. B. & Desm.—On *Nyssa, Quercus*, and *Cyrilla*. Car. Inf. No. 2088, 2776, 3059, 3060.

"Forming black hispid patches, consisting of fascicles of fastigiate threads, which bear here and there globose sporangia."

The genus *Glenospora* was, however, instituted several years earlier by Berkeley and Desmazières, in a paper "On some moulds referred by authors to *Fumago*, and on certain allied or analogous forms" (*Journ. Roy. Hort. Soc.* IV (1849), 243–260). In that paper the authors stated:

"We conclude our memoir with the notice of a new genus, which is abundantly produced in certain situations in South Carolina, though the fructification is of rare occurrence. It is generally, if not always, accompanied by a new species of *Myriangium*, but has not the slightest connexion with it. The threads are cylindrical, inarticulate, fasciculate, creeping widely over the matrix of a shining black; giving off branches from the fascicles, which are themselves fasciculate, and often confluent with one another. These are at times contained in a common sheath, exactly as in the genus Microcoleus. They are for the most part barren, but occasionally fructification is produced on

the edge of the fascicles, on the free-branched apices of the threads. It consists of large, globose, dark spores, which contain a single nucleus; from which circumstance we have called it *Glenospora*. It is analogous to *Acremonium*, but that belongs to the group of *Mucedineae*, while this belongs to *Dematia* —resembling closely the mucedinous genus *Brachycarphium*, Berk., discovered in amber by Dr Thomas, and figured in the 'Annals of Natural History' for December, 1848.

"*Glenospora*, Berk. and Desm.

"Hyphasma repens late expansum, floccis fasciculatis supra articulatis communi membranâ vestitis ramosis, prope apices è fasciculis liberatos fructificantibus contextum. Sporae amplae globosae, saepe binae coloratae, nucleo globoso. Analogon *Acremonii* quoad fructum, *Brachycarphii* quoad Hyphasma et apices filamentorum liberatos fructificantes. Vix ulli *Dematiearum* arctè affinis.

"Hab. in corticem *Nyssae aquaticae*, *Aceris rubri*, et *Prini verticillati*, frequens in sylvis humidis et paludibus Carolinae Inferioris, *Myriangii* saepissime si non semper socius.

"*Glenospora Curtisii*, Berk. and Desm. Curt. No. 1442, 1021. (Fig. 11). On the bark of Nyssa aquatica, Prinos verticillata, and Acer rubrum. Extremely common in South Carolina.—Rev. M. A. Curtis.

"It may be remarked, that Mr Thwaites found a very similar production, only with hyaline threads, mixed up with *Coccochloris Brebissonii*, growing in dripping places near Bristol. The fructification and the whole structure are very similar. At present it has not been found by itself, so as to enable him to ascertain its habits and colour when freely developed. The spores are dark-brown, and have a pretty effect on the colourless filaments. This may be called *Glenospora Thwaitesii*, but we have not thought it necessary to give specific characters, as we have scarcely sufficient information for this purpose. The spores of *G. Curtisii*, it may be observed, when viewed by transmitted light, have a lilac tinge, as have also the threads in portions of the stratum, but not constantly."

The characters of *Glenospora* in the description of 1849 do not entirely agree with those of the description of 1876. In particular, the mycelium or stroma was described in the former as repent, while in the latter it was said to be fastigiate, the species, *Glenospora Curtisii*, forming black hispid patches. For *Glenospora Curtisii*, 1849, Berkley cited Curtis 1442, 1021, but for *Glenospora Curtisii*, 1876, he cited Curtis 2088, 2776, 3059, 3060.

As regards *Glenospora ramorum* (Schw.) B. & Br., I have not

been able to find any reference to that name by Berkeley and Broome. In Broome's interleaved copy of Hoffmann, *Index Mycologicus*, now in the British Museum, he has entered "*Glenospora ramorum* B. & C., F.C. exsicc. I. 87." The latter reference is to Ravenel's Fungi Carolinae Exsiccati, in which no. 87 of century 1 is labelled "*Glenospora ramorum* Berk. & Curt. *G. Curtisii* Berk. & Desm. *Dematium ramorum* Schwein. Cortice viv. Nyssae." Broome, therefore, did not claim any authorship of *Glenospora ramorum*.

Saccardo gave, as synonyms of *Glenospora ramorum*, *Rhacodium ramorum* Schw., Carol. no. 1362, and *Oedemium ramorum* Fries, *Syst.* III, 345. Fries (*loc. cit.*) described *Oedemium ramorum*, with the synonym *Racodium ramorum* Schwein. Car. n. 1362, as "Fibrae contiguae, opacae, nigrae, tenues, parce ramosae, crustam tenuem tomentosam ad 4 unc. usque expansum sistunt; fertiles surgunt. Sporae e latere floccorum breviter, at evidenter pedicellatae, quare secedentes appendiculatae, opacae, nigrae, exacte globosae, in aqua vero secernentes sporidia minuta, numerosissima, globosae, pellucida, quibus evacuatis sporae membranaceae pellucidae. A praecedente [O. atrum] differt ut *Mycogone* a *Sepedonio*, sed si tam subtiliter genera distinguimus, singula genuina species peculiare genus. Ad ramos vivos *Quercuum* et *Andromedae arboreae* in Carolina (v.s.)."

Fries' description of *Oedemium ramorum* was drawn up from a specimen of "*Racodium ramorum* Schwein.," but the collector's name is not stated. Saccardo's description of *Glenospora ramorum* is evidently based on that of Fries, though the length, 4 inches, in the latter becomes 2–3 cm. in the transcription.

A search through Schweinitz's lists, however, has failed to reveal any species, *Racodium ramorum*. *Synopsis fungorum Carolinae superioris*, no. 1362, cited by Fries, is *Racodium ramosum* Schwein., described as "R. cohaerens hinc inde floccosum nigrum tenue, filis subramosis distinctis. Ramos vivos quercinos et Andromedae arboreae undique investit, quatuor fere uncias latum. Affine rupestri." Similarly, the name *Dematium ramorum* Schwein., cited by Ravenel, does not appear to have been published by Schweinitz.

It will be noted that in Fungi Carol. Exsicc. 1, 87, Ravenel regarded *Glenospora ramorum* B. & C. as synonymous with *G. Curtisii* Berk. & Desm. A specimen in Herb. British Museum may, perhaps, throw some light on this. It is labelled in Curtis's script, "*Glenospora ramorum* M.A.C. *Glenospora Curtisii* Berk. & Desm. in ramul. viv. Nyssae. Carol. Septentr. M.A.C." To that is added a printed label "coll. M. A. Curtis. Distrib. W. G. Farlow," and a manuscript label, "*Glenospora Curtisii*" by Farlow.

It would appear that *Glenospora ramorum* was Curtis's name for the species which Berkeley and Desmazières described as *Glenospora Curtisii*, but the former name was not published. I have not seen any evidence that Curtis considered this species identical with *Racodium ramosum* Schw., though it is quite probable, from the description of the latter, that it is.

Ravenel distributed Fungi Carol. Exsicc. 1, 87 as *Glenospora ramorum* B. & C., but in his Fungi Americani Exsicc., no. 333, nearly thirty years later, he issued the same species as *Glenospora Curtisii* B. Again, Herb. British Museum purchased Ravenel's herbarium in 1891, but none of the specimens so obtained is indisputably labelled *Glenospora ramorum*. These specimens are as follows:

(A) "113. *Glenospora Curtisii* B. on *Carpinus*. Gainesville, Fla. H. W. R." in Ravenel's writing.

(B) "Ravenel, Fungi Americani Exsiccati, no. 333. *Glenospora Curtisii* B. in cortice Nyssae et Carpini, Darien, Georgia": and an unnumbered duplicate, both with printed label.

(C) "*Glenospora ramorum* B. & C. *G. Curtisii* B. & Desm. Aiken. S. C. Cortice Nyssae. H. W. R." in Ravenel's writing. Subsequently Ravenel crossed out "*ramorum*" and substituted *Curtisii*, deleting also the C. of "B. & C." This specimen is probably a duplicate of "Fungi Exsiccati selecti ex herb. M. C. Cooke. *Glenosporium* (sic) *ramorum* B. & C., on *Nyssa*, Aiken, S. C. Ravenel," four copies of which are in Herb. Kew.

(D) "1195. *Glennospora Curtisii* Berk. & Desm. *Glennospora ramorum* Berk. & Desm. Hieme. Ramulis Nyssae. S. C. H.W.R." in Ravenel's writing.

(E) "3207. *Glennospora ramorum* Berk., on living *Myrica cerifera*. Darien, Ga. March 81. H. W. R." in Ravenel's writing, the name being in pencil and having "*Curtisii*" written over "*ramorum*." In Herb. Kew, there is a duplicate of this, marked by Ravenel, "Looks like *Glenospora Curtisii* Berk. March, 1881, on living *Myrica cerifera*. Darien, Ga. H. W. R. never saw the species on *Myrica*."

The evidence of these specimens from Ravenel's herbarium favours the supposition that Ravenel used first the name *Glenospora ramorum* and later *Glenospora Curtisii* for the same species.

Both Herb. Kew and Herb. British Museum have copies of Ravenel, Fungi Carol. Exsicc. 1, 87, *Glenospora ramorum* B. & C.; Ravenel, Fungi Americani Exsicc., no. 333, *Glenospora Curtisii*; and Thuemen, Mycotheca universalis, 292, *Glenospora ramorum* Berk. & Curt. (coll. J. B. Ellis).

Herb. Kew has also "*Glenospora Curtisii*. N. Jersey. in cort.

viv. Nyssa" in Berkeley's handwriting; Curtis 2088, 2776, 3059, 3060; a specimen numbered 4051 (in pencil), marked by Ellis, "I think this ought to be *Glenospora melioloides* B. & C., but have no specimen for comparison," and stamped "Herb. Mycol. M. C. Cooke. 1885"; a duplicate from Ellis of Thuemen 292; "*Glenospora Curtisii* B. & Desm. ram. viv. Nyssae. Carolina," in Curtis's script, *ex* Herb. Cooke; "*Glenospora ramorum* B. & C. *forma*. Aiken. S. Car." written by Cooke on his usual small envelope; "*Glenospora Curtisii* B. & C. Florida. Rav." written by Cooke on small envelope.

Whether labelled *Glenospora Curtisii* or *Glenospora ramorum*, all but three of these specimens are the same species. The exceptions are Curtis 2088, Ellis 4051, and Cooke's "*Glenospora ramorum* B. & C. *forma*."

The type specimens of *Glenospora Curtisii* Berk. & Desm., 1849, are Curtis 1442 on *Prinos verticillatus* and Curtis 1021 on *Acer rubrum*. Berkeley's record of *Nyssa* as a host plant in 1849 was based on Curtis's statement (MS.) that the fungus was common on *Nyssa*. Unfortunately neither 1442 nor 1021 is in Herb. Kew or Herb. B.M.

In his description published in 1849, Berkeley stated that *Glenospora Curtisii* was generally, if not always, accompanied by a new species of *Myriangium*. The latter was *Myriangium Curtisii*. Berkeley sent specimens of this *Myriangium* to Montagne, and one of these was Curtis 1442, which is now in Herb. Montagne in Herb. Paris, among the lichens *sub Myriangium Curtisii*. Montagne returned to Berkeley a drawing of the *Myriangium* and another of the *Glenospora*, the latter inscribed "Mucédinée du Myriangium." These drawings are now in Herb. Kew.

Berkeley also sent specimens of this *Glenospora Curtisii* to Thwaites (at Bristol). Dr C. H. Gadd has kindly searched the collection of fungi which Thwaites took out to Ceylon shortly afterwards, and informs me that it does not contain this species.

Consequently, as far as is known at present, the only specimens of Curtis 1442 in European herbaria are in Herb. Montagne in Herb. Paris. One of these is included among the lichens *sub Myriangium Curtisii*; it contains the *Myriangium*, with scanty remains of a *Glenospora*, which are wholly repent. Montagne detached almost the whole of the *Glenospora* and included it in his herbarium under that name. The latter specimen is marked "no. 1442 *Glenospora* Berk. cum *Myriangie Curtisii*. Carol. Sup. Berk.," and consists of a few very small fragments, mounted on a sheet of mica; it includes a minute stroma of the *Myriangium*, and several fragments of the *Glenospora*, which, as far as can be determined, were wholly repent. Montagne's figures

show repent mycelium only, and are inscribed "Mucédinée qui accompagne sous forme de mycelium le *Myriangium* de la Caroline Super. Berkeley. *Glenospora* Berk. Sporae lilacinae, primo hyalinae."

Berkeley found that in the specimens which he first received from Curtis, *Glenospora Curtisii* occurred in company with *Myriangium*. That association, however, does not appear to occur frequently. Of all the specimens of *Glenospora* and *Myriangium* in Herb. B.M. and Herb. Kew, there is only one, viz. Ravenel, Fungi Americani Exsiccati, no. 332, in which both fungi are present. The reason for this association is that both the *Myriangium* and the *Glenospora* are parasitic on scale insects.

From Berkeley's original description (1849) and Montagne's specimens of Curtis 1442, it is clear that the *Glenospora Curtisii* of that date was indentical with the majority of the specimens which have since been issued under that name and under the name *Glenospora ramorum*. The fungus forms a thin, black film or crust, over-running scale insects on living branches. The film is composed of thick-walled, septate hyphae 3–4 μ diameter, sometimes irregularly flexuose and intertwined, sometimes united laterally into strands. The hyphae are blackish brown, becoming hyaline or lilac-grey at the apex, and merge here and there into an amorphous hyaline sheet. In some examples, at the margin of the stroma, the repent mycelium forms a series of stars, with curved rays up to 20 μ broad which branch and anastomose and frequently give off separate hyphae laterally. These rays are black and shining and consist of hyphae fused laterally to one another. Ladder connections occur between the hyphae of these strands. Further back, the strands have branched, or have given off single hyphae, until at first a network, and finally a continuous sheet, is produced.

There is no sheath round the strands, but their margins may be bordered by a hyaline or pale brown amorphous film, and a film of the same character may fill the meshes of the network.

The hyphae bear globose, spore-like bodies laterally, either on very short pedicels or on short lateral branches. These occur on hyphae which run singly, or diverge from the strands. They may occur singly, or several on the same branch. A lateral branch 20 μ long in one instance bore three of these bodies, one terminal and the other two alternate and equally spaced. Another branch, of about the same length, bore five, two opposite pairs and one terminal, forming a series in contact. Sometimes two, sometimes three of these pseudo-conidia occur at the apex of a lateral branch. They are globose, moderately thick-walled, smooth, at first lilac, then blackish brown.

Measurements on different specimens gave a diameter of 7–9 or 8–12 μ. The "single nucleus" described and figured by Berkeley was not evident on the spores examined.

The specimens which appear to differ from *Glenospora Curtisii* Berk. & Desm. are Curtis 2088, Ellis 4051, and Cooke's "*Glenospora ramorum* B. & C. forma. Aiken S. Car." Unfortunately, Curtis 2088 is the type specimen of the *Glenospora Curtisii* B. & C. of 1876.

In the specimen Curtis 2088 in Herb. Kew, the fungus forms a black hispid patch. It consists of a thin basal layer, from which arise close-set, somewhat rigid fascicles of hyphae. The basal layer is composed of branched, irregularly flexuose and intertwined, thick-walled hyphae, about 3 μ diameter, varying in colour from blackish brown to hyaline, the hyphae merging here and there into a hyaline amorphous sheet. The erect fascicles are up to 1·8 mm. high, and 0·1 mm. in diameter below, tapering upwards to a subacute apex, and are composed of hyphae similar to those of the basal layer, but regular. These hyphae are firmly united to one another laterally, and occasionally two or three fascicles fuse into one at a short distance from the base. Some of the hyphae of the fascicles are beaded with narrow-oval swellings at close intervals. I did not find globose conidia in this specimen.

Ellis 4051 is similar to Curtis 2088, but the beaded hyphae were not observed in it. Globose conidia were not found.

The specimen, "*Glenospora ramorum* B. & C. *forma*" from Cooke's herbarium is a thin, black film, from which arise widely scattered groups, each of a few erect bristles. The black film is similar to that of *Glenospora Curtisii* and contains globose conidia. The erect fascicles are shorter than in Ellis 4051, but of the same structure; they bear a few globose conidia, more especially on loose hyphae near the base.

It is possible that the last specimen may be *Glenospora Curtisii*, in which case that species can produce erect fascicles. But Curtis 2088 and Ellis 4051, which have no globose conidia, are more probably another species.

The globose bodies do not become detached and are probably not conidia. It would appear more probable that the specimens should be referred to *Septobasidium*, and that the globose bodies are probasidia. Curtis 2088 may be parallel to *Septobasidium pteruloides* (Mont.) Pat. (*Lachnocladium ramcale* B. & Br.). These points, however, can be determined only by further investigations in the type locality.

The various species which have been referred to *Glenospora* in medical mycology do not appear, from the descriptions, to belong to that genus.

Mr J. Ramsbottom, of the British Museum, has given me the full benefit of his wide knowledge of the collections and memoranda in that herbarium during the preparation of this paper, and I desire to record my sincere thanks for his valuable assistance.

Conclusions.

The genus *Glenospora* was established by Berkeley and Desmazières in 1849, not by Berkeley and Curtis in 1876.

Glenospora ramorum was first published by Ravenel in Fungi Carol. Exsicc. 1, 87, and was Curtis's name for *Glenospora Curtisii*.

Berkeley's *Glenospora Curtisii* of 1876 is not the same species as his *Glenospora Curtisii* of 1849, in so far as the first specimen (Curtis 2088) cited by him for the former is concerned.

The genus *Glenospora* is probably to be referred to *Septobasidium*.

OBSERVATIONS ON SOME SCOTTISH UREDINEAE AND USTILAGINEAE. II*.

By Malcolm Wilson, D.Sc., F.R.S.E., F.L.S., Reader in Mycology, University of Edinburgh, and J. S. L. Waldie, B.Sc., C.D.A., Assistant in Mycology.

Puccinia le Monnieriana Maire.

Teleutospores on *Cnicus palustris* Hoffm. Drumlanrig near Thornhill, Dumfriesshire, September, 1924.

Teleutospore sori hypophyllous, seated on slightly depressed yellowish spots about 2–4 mm. in diameter, in small irregular dense groups about 2–3 mm. wide, often confluent, pulvinate, surrounded by the ruptured epidermis, dark brown; teleutospores clavate, apex rounded, truncate or acutely conical, strongly thickened (8–14 μ), constricted at the septum, rounded or often attenuate at the base, smooth, yellowish brown, 40–55 × 14–21 μ; pedicels hyaline or brownish near the apex, thick (6–8 μ), persistent, up to 65 μ long.

This species was first found by Maire (*Bull. Soc. Mycol. France*, XVI (1900), 65) near Luneville, France, and has also been recorded from Portugal. Only teleutospores have been found and this appears to be the only spore-form. The groups of sori occur only on the under surface of the leaf, those near the margin

* The first paper dealing with the subject appeared in *Trans. Brit. Mycol. Soc.* IX (1924), 135.

being irregularly grouped while those nearer the mid-rib are often somewhat circinately arranged. The sori are strongly pulvinate and form compact masses. According to Maire the spots are bordered with violet, but this was not observed in our specimens.

This species differs from all others found on the genus *Cnicus* by the very strongly thickened wall at the apex of the spore, being most nearly approached in this character by *P. Cnici-oleracei* Pers. It is distinguished from this species by the smaller, often confluent, sori, and by the more strongly thickened, usually pointed, teleutospores.

Maire also records the rust in September and it appears to be a species developing in the autumn. The specimens were found during the excursion of the Scottish Cryptogamic Society, on plants growing in a damp mixed wood, and the species was recorded in their annual report for 1924.

Uromyces sparsus Lév.

Uredospores and teleutospores on *Spergularia marginata* Kittel (*S. media* Pers). Collected by Mr J. K. Leven near Longniddry, Haddington, June, 1925.

The sori are present on the stems, leaves and sepals. This species has been recorded from Kent on *S. rubra* but is apparently very rare in England. It has not been previously recorded from Scotland.

Melampsorella Caryophyllacearum Schroet.

Uredospores on *Cerastium arcticum* Lange. Collected by Mr R. J. Pealling, Ben Nevis, August, 1924.

Not previously recorded on this host. *Cerastium arcticum* is not found at lower than about 2500 ft. and no species of *Abies* are present in the vicinity at anything approaching this altitude. It is difficult to understand, in this case, how *Abies* sp. can function as the alternate host.

Cronartium ribicola Fisch. de Waldh.

Aecidia on *Pinus parviflora* Sieb. & Zucc., Murthly, Perthshire, June, 1924.

Not previously recorded on this host in Britain.

Aecidium importatum P. Henn.

On leaves and petioles of *Peltandra virginica* (L.) Kunth. Royal Botanic Garden, Edinburgh, June, 1924.

This was described by Hennings in 1895 (*Verh. Bot. Ver. Prov. Brand.* xxxvii (1895), pp. xxv and 12) who found it in the Berlin Botanic Garden on plants imported from North America.

The spermogonia appear first in June on the petioles and

under side of the mid-rib of the leaf. They are conical and reddish brown in colour. The aecidia appear in July in the same positions. They are at first hemispherical and orange-yellow and remain long closed, becoming almost cylindrical before opening. After the orange aecidiospores are shed the pseudoperidium persists as a white structure.

Spores 25–30 × 20–27 μ, spherical or elliptical, often angular.

There is an abundant colourless mycelium in the mid-rib and petiole. The mycelium persists in the root stock and produces the aecidia each year in the early summer, the leaves formed later not being attacked. The host plant does not appear to suffer at all from the presence of the fungus. *Aecidium importatum* Henn. is not known from North America. *Aecidium Caladii* Schw. (*Uromyces Caladii* Farl.) is regarded by Arthur (*North American Flora*, VII (1912), 236) as co-specific with the form on *Peltandra virginica*, i.e. *Uromyces Ari-Virginici* Howe.

The origin of the plants at Edinburgh is not known, but it is unlikely that they were obtained from Berlin. They have been producing the aecidia for several years and were probably infected when introduced into the garden.

Uredo Glyceriae Lind.

On *Glyceria maritima* R. Br. Collected by Miss M. M. B. Knagg, near Linlithgow, Firth of Forth, May, 1925.

Sori epiphyllous, scattered, rounded-elliptic or elongated, up to 1 mm. long, surrounded by the ruptured epidermis, yellow; paraphyses numerous, clavate-capitate, 50–60 μ long 14–18 μ wide at the apex, hyaline or pale yellow above, membrane up to 2 μ thick; uredospores globose, ovate or ellipsoid, verrucose-echinulate, subhyaline or yellow, 24–30 × 20–25 μ, epispore 1–1·5 μ thick, with 8–10 scattered germ pores.

The above description is copied from Sydow (*Monographia Uredinearum*, IV (1924), 540) and Lind (*Danish Fungi*, p. 343). In the Scottish specimens the spores are slightly smaller than described above, but in other respects the specimen agrees closely with the description. The species has been previously recorded only from Denmark.

Urocystis Anemones (Pers.) Schroet.

On the petioles of *Ranunculus Ficaria* L. near Edinburgh, May, 1924, and on the stems and leaves of *Trollius europaeus* L. near Lochranza, Isle of Arran, July, 1926.

The forms on *R. Ficaria* and *T. europaeus* do not appear to have been previously recorded in Britain. Trail (*The Scottish Naturalist*, IV (1889–90), 370) lists *U. Anemones* as occurring on *Anemone nemorosa* L. and *Ranunculus repens* L. in Scotland

and in foreign countries it has also been recorded on several other hosts. Sydow (*Oesterr. botan. Zeitschr.* 1 (1901), 12) recorded the occurrence of this smut on *Trollius europaeus* in the Tyrol. On *Trollius* the spore balls consist of two or three thick-walled spores surrounded by a number of very regularly arranged sterile cells, while on *Ranunculus Ficaria* the thick-walled spores are usually three or more in number. In colour and in structure the spores agree with the description of those of *Urocystis anemones* given by Saccardo (*Sylloge Fungorum*, VII (1888) 518). On *Trollius* the spore balls measured 25–35 μ, while the spores were 15–18 μ.

STUDIES ON RHIZOCTONIA CROCORUM (PERS.) DC. AND HELICOBASIDIUM PURPUREUM (TUL.) PAT.*

(With Plates XI–XIV.)

By W. Buddin and E. M. Wakefield.

THE present paper is the outcome of observations and experiments made during the past three years with the object of elucidating, if possible, the life history of the fungus *Rhizoctonia Crocorum* (Pers.) DC. Owing to unexpected difficulties and complications which developed in the course of the cultural work, the results obtained up to the present can only be regarded as preliminary, and are not put forward with any claim to finality. As, however, for various reasons it seems unlikely that any more conclusive results will be obtained by the authors for some time, this account of what has been done is published in the hope that it may be of service to other workers.

The investigation arose out of an identification made in the autumn of 1922. At that time there was received at Kew from the Horticultural Research Station at Long Ashton a stump of black currant (*Ribes nigrum*) which had a dense felted violet growth round the main stem. The growth was sterile, but from previous knowledge of the habit and structure of *Helicobasidium purpureum* (Tul.) Pat. little hesitation was felt in suggesting that it was probably this species. Subsequently, however, it was found that the roots of the *Ribes* showed the bodies known variously as microsclerotia, or better as "infection cushions"

* Paper read at the International Congress of Plant Sciences, Ithaca, N.Y., August 19th, 1926.

or "corps miliaires," which are characteristic of attack by *Rhizoctonia Crocorum*. The question then arose as to whether the first identification had been an error, or whether *Helicobasidium purpureum* could conceivably be the long-sought-for perfect stage of the *Rhizoctonia*.

A priori the latter suggestion seemed to be more feasible than some of those which had been advanced at various times. *Helicobasidium* is a Basidiomycete, to which group the fructification of *Rhizoctonia* would most probably belong. Further, one species, *Helicobasidium Mompa*, is known to be a root-parasite of the mulberry in Japan, and to produce sclerotia on the roots; while another species, *H. longisporum* Wakef., occurred in association with a *Rhizoctonia*-like mycelium on roots of cacao in Uganda, and was suspected of parasitism.

Rhizoctonia Crocorum has long been known in the sterile state as a root parasite of numerous plants, and from time to time various suggestions have been made as to its mode of reproduction. A complete summary of the literature on the subject was given by Duggar (1) in 1915, and his paper should be consulted for further details. The two suggestions which have received most attention are those of Fuckel and Eriksson. The former (2) found a Pyrenomycete, *Leptosphaeria circinans* (Fuck.) Sacc., associated with *Rhizoctonia* on roots of lucerne, and suggested a connection between the two fungi. The same association has also been noticed by other observers. Duggar, however, germinated spores of *Leptosphaeria circinans* and obtained from them a mycelium which had no resemblance to that of *Rhizoctonia*. Eriksson, no doubt influenced by the discovery that the perfect stage of *Rhizoctonia Solani* is a *Corticium* (or *Hypochnus*, as it was first called), examined some material, preserved in spirit thirteen years before, of certain weeds which had been planted in soil inoculated with *Rhizoctonia Crocorum* from carrots. As a result he announced that he had found a *Hypochnus* which he believed to be the perfect stage of the *Rhizoctonia*, and he gave to it the name *Hypochnus violaceus* (3)*. Unfortunately he gave no description whatever of his supposed *Hypochnus*. It is to be noted that he claimed to have found only *basidiospores*, and possibly did not see basidia. In the absence of any confirmatory evidence it has not been possible to accept Eriksson's conclusion.

In a subsequent paper (4) Eriksson used his supposed discovery of a *Hypochnus* stage connected with *Rhizoctonia* on carrot as

* In the 3rd edition, 1926, of Delacroix and Maublanc, *Maladies des Plantes Cultivées*, p. 144, the new combination *Corticium Erikssonii* is used for this supposed perfect stage. As Eriksson's name was a *nomen nudum*, the change is superfluous.

an argument in favour of the view that the Rhizoctonias of carrot and lucerne are distinct, since he had already concluded that the latter was connected with *Leptosphaeria circinans*. He further suggested that the *Rhizoctonia* found on asparagus might be yet a third species and possibly connected with *Diaporthe* (or *Leptosphaeria*) *Asparagi* Fuck. The present authors (5) have already shown that cross-inoculations lend no support to this idea. In 1923 and 1924 they were able to produce typical root-rot in carrots with pure cultures of *Rhizoctonia* isolated from red clover, and since that time they have carried out successful inoculations on various leguminous plants, including lucerne, with strains of *Rhizoctonia* derived from sugar beet, from potato, and from mangold.

Obviously all these speculations as to the connection of associated spore-forms were without experimental proof. This was no doubt partly due to the failure of all the early attempts to grow *Rhizoctonia Crocorum* in pure culture. This difficulty was finally overcome by Van der Lek (6) who, in 1917, succeeded in obtaining pure cultures on malt agar. He did not, however, pursue the work, and his cultures have been allowed to die out.

Not wishing to add yet another unproven guess to an already somewhat formidable list, we determined to test our *Helicobasidium* hypothesis, if possible, by means of pure cultures and inoculations, and to that end set out to obtain material for experiment. Fortunately, just at the time excellent material of *Rhizoctonia* on red clover was received from Mr W. M. Ware, who kindly responded to a request to supply relays of specimens. The successful starting of pure cultures has already been recorded (5). It may be mentioned here that by the methods described in that paper successful isolations of undoubted *Rhizoctonia Crocorum* from various plants have since been made.

Field Observations.

The problem of obtaining fresh material of fertile *Helicobasidium* for the purpose of making cultures for comparison seemed much less likely to be readily solved. The fungus had apparently been found only once in this country, namely at Alresford, Hants, on ash bark. As the species is more often recorded in France, an effort was made to obtain fresh specimens from mycologists there, but without success. Again, however, a fortunate coincidence occurred. Hearing that Mr Ware, who had been continuing his work on the clover disease (7), had found an associated spore form, the authors wrote explaining what they wanted, and inquired whether by chance Mr Ware's fungus might be this species. Mr Ware at once sent drawings and specimens, which the authors were delighted to recognise

as their much wanted *Helicobasidium*. They would like to take this opportunity of expressing their appreciation of the great generosity and helpfulness of both Professor Salmon and Mr Ware, who handed over all their material of the fungus.

(1) On April 30th, 1923, the senior author visited Wye, and in company with Mr Ware examined the field of red clover where both *Rhizoctonia* and *Helicobasidium* had occurred. *Helicobasidium* was found in small areas here and there through the field. It was difficult to see on account of the tall growth made by the clover by this time, but sometimes it was possible to pick out a likely spot by the somewhat sickly yellowish appearance of the plants. The fungus occurred close to the ground, surrounding the bases of the clover stems and the lower leaf-sheaths, and spreading outwards from them to surrounding objects, as oat stubble, grass, stones, soil, etc. Numerous clover plants showing the fungus were dug up and taken away with the surrounding soil intact. The following day the soil was carefully washed away, and in many cases the *Helicobasidium* was found to be associated with plants which showed typical root-rot due to *Rhizoctonia Crocorum* (Plate XIII, fig. 32). The association was so close and the colour of the mycelium of both so similar, that connection seemed most probable, although it was not possible actually to trace the fine hyphal strands continuously from the infection cushions to the fertile *Helicobasidium*. In most of the affected plants the root-rot had proceeded so far that the dead cortex slipped off easily, and frequently only a stump of the tap-root remained. Further, at such a late stage the filamentous mycelium of the *Rhizoctonia* is less evident than in the early stages of disease, and it was sometimes difficult to find any external hyphae running along the diseased roots.

(2) On October 13th, 1924, Miss J. C. Eyre sent a small box of resupinate fungi collected at Ipplepen, near Newton Abbot, Devon. Amongst them was what appeared to be *Helicobasidium purpureum*, though as yet sterile, growing on ash bark and on some small green stems. Miss Eyre fortunately was able to find again the spot whence it came, and in company with her the senior author thoroughly examined the locality about ten days later. The fungus was completely covering a thick ash root which had become exposed just inside a rabbit burrow. Some of the finer roots which were hanging round the mouth of the burrow were also covered with the same beautiful violet felt, while within an area of about a square yard the fungus occurred also on dead twigs and leaves and sometimes attached to the base of the stems of Dog's Mercury (*Mercurialis perennis*), which was practically the sole ground vegetation at that spot.

After a careful preliminary survey it was decided to leave the large mass of mycelium on the ash root undisturbed, in the hope of obtaining spores later. Digging was undertaken round about in order to excavate any other roots that might be harbouring *Rhizoctonia*. Some fine ash roots, an ash seedling, and numerous plants of *Mercurialis* that were in contact with the aerial felt were thus removed and taken away for more detailed examination. After washing to remove the soil, all the fine ash roots, and also the root of the ash seedling, were found to be invested with either fine strands or even fairly thick cords of deep, reddish purple mycelium, running backwards from the aerial felt. In none of the ash roots however were any infection cushions observed.

The *Mercurialis* provided more definite information. Similar strands of the purplish mycelium were found running along the stolons from plant to plant, and in one case were clearly seen to be connected with the purplish felt on an ash twig which had been lying on the surface of the ground beside the plant. Of greatest interest was the fact that this plant, and also many others of *Mercurialis* dug up from the area infested by the fungus, showed dark decayed roots and stolons from which the cortex came away easily. With the aid of a lens, numerous bodies resembling "corps miliaires" were detected on these decayed roots and underground stems, and that this was in reality their nature was confirmed subsequently by microscopic examination. The "corps miliaires" or infection cushions of *Mercurialis* agree exactly in structure with those found on potato, clover, etc., affected with Violet Root Rot, but are slightly larger than those on clover with which they were compared. Plate XIV, figs. 33 and 34, shows a plant of *Mercurialis perennis*, with diseased roots and stolons, the mycelium from which is connected with encrusting mycelium on the adjacent debris. Attempts to isolate the fungus from the roots failed in this case, owing to the fact that they were too badly rotted and consequently contaminated with other more rapidly growing organisms. Fig. 34 shows a typical example of a rotted stolon, with cortex becoming detached, and numerous infection cushions.

Miss Eyre kindly undertook to keep the locality under observation. Investigation of all available records of *Helicobasidium* had indicated that the fructification occurs apparently only in spring. It was hoped therefore that the large mat of mycelium which had been left intact on the ash root would produce spores in the following spring months and thus establish another case of close association of *Helicobasidium* and *Rhizoctonia*. Climatic conditions during the winter were unfavourable, and by April,

1925, only a collapsed brownish membrane was apparent. Fortunately, however, satisfactory evidence has since been obtained. At the beginning of March of the present year (1926) Miss Eyre reported that fresh violet mycelium was appearing again in the same spot, both on the large ash root and on the smaller plants around. Towards the end of March, with the onset of warmer weather, she was successful in finding the fertile *Helicobasidium* hymenium on the aerial felt, and forwarded specimens for confirmation. Examination of these showed that the hymenium had formed sometimes above the old collapsed mycelial weft, and was growing from it, so that there could be no doubt of the continuity of this sporing stage with the mycelium previously observed. In other cases the fructification was not obviously connected with any old mycelial felt.

(3) On April 10th, 1925, Miss Eyre found good fertile specimens of *Helicobasidium* in another locality, and forwarded material for examination. A week later this ground was carefully examined and digging operations undertaken.

Here the *Helicobasidium* occurred on a low hedge-bank which divided a narrow lane from a field. In a small area, a square yard or less, it was found in abundance, encrusting the bases of various plants growing there, notably *Urtica dioica*, *Digitalis purpurea*, and occasionally small grasses. It occurred also on the bare soil just inside a rabbit burrow*. Examples of all the plants with which the fungus was associated were carefully uprooted and taken away for examination. After the roots had been washed free from soil it was found that those of *Digitalis* and the grasses were perfectly clean and healthy. In the *Urtica*, however, unmistakable root-rot was present, again with infection cushions such as are typical of *Rhizoctonia Crocorum*. Plate XIV, fig. 35, shows an example of *Urtica* with the fructification of *Helicobasidium* at the base of the stem, while the roots and runners bear the infection cushions of *Rhizoctonia*.

The original diagnosis of the fungus on black currant as *Helicobasidium purpureum*, made before its association with *Rhizoctonia* on the roots of the same plant had been observed, has thus been justified. On three further hosts, and in three widely separated localities, there has been found close association of the Basidiomycete with root-rot having the characters of attack by *Rhizoctonia Crocorum*.

* A similar frequent production of the fructification in holes in the ground occurs in the fungus causing Texas root-rot of cotton, *Phymatotrichum omnivorum* (Shear) Duggar. In both fungi the requirements for the production of spores appear to be shade and a humid atmosphere. (See King, C. J., in *Journ. Agr. Res.* XXVI, 1923, p. 407.)

Nomenclature and Description of the fungus *Helicobasidium purpureum.*

The basidiomycetous fungus in question was first described and figured by Tulasne (8, 9) under the name *Hypochnus purpureus.* His description of its habitat, at the foot of small trees or covering living and dead parts of small herbaceous plants, its distinctive violet colour, and his excellent figures of the basidia and spores leave no doubt as to the fungus he had before him.

In 1885 Patouillard (10), having apparently overlooked Tulasne's work, described the species as new and created for it the genus *Helicobasidium,* characterised by the peculiar curved, septate basidia. Fortunately he used the same specific name, *purpureum,* so that no change was necessary when the identity with Tulasne's fungus was recognised. In a later work Patouillard himself cited *H. purpureus* Tul. as a synonym of his *Helicobasidium purpureum* (*Essai Taxon.*, 1900, p. 12). Meanwhile Schroeter (11) had founded the genus *Stypinella* on Tulasne's species; his genus was, however, antedated by Patouillard's and cannot stand.

Helicobasidium purpureum (Tul.) Pat. has been recorded in Europe from several districts of France, from Germany, and at the time the present work was begun once only from England. It has not yet been found in America, but *Helicobasidium Peckii* Burt, founded on an old collection from the Adirondack Mountains, seems to be very closely allied, differing mainly in the colour, in which no trace of violet is mentioned. As the colour of old dried specimens of *H. purpureum* is frequently hardly violet, but cinnamon-drab*, it seems possible that *H. Peckii* may prove to be the same species.

H. purpureum occurs sometimes on bark at the base of trees, on fallen branches, leaf debris, etc., but more often it is found encrusting the bases of small herbaceous plants, after the manner of *Sebacina incrustans* Tul. It is usually found to be quite separable from its above-ground support, and for this reason Bourdot, when describing it in his "Hyménomycètes de France" (*Bull. Soc. Myc. Fr.* xxv, 1909, p. 17), added "il n'est point parasite." It is interesting, however, to note that in the description accompanying Roumeguère's Fungi Gallici Exsiccati, No. 3706 (*Rev. Myc.* 1886, p. 146), evidently compiled from notes made by Barla, it is stated that the fungus sometimes covers a great extent of its support, and envelopes the whole root-system of the plant, which it soon destroys. This

* The colour-terms used throughout this paper are those of Ridgway, *Color Standards and Color Nomenclature.*

particular collection, made by Barla in the neighbourhood of Nice, was described as having a conidial form, which, according to Patouillard(12), occurred in March, before the basidia appeared. The statement is particularly interesting in view of the fact that a conidial fungus, to be described later, has frequently occurred in cultures made by the writers, although so far it has not been seen in nature. The odour of lighting gas, which was attributed to Barla's fungus, has not been noticed in any British specimens of *Helicobasidium*.

As far as available records and the writers' experience show, *H. purpureum* occurs in fertile condition during only a very limited period of the year, roughly from the end of March till the latter part of May, and even then is doubtless dependent on the occurrence of favourable climatic conditions. It is at its best in very mild, moist weather such as occurs in the south of England about April, and it is extremely sensitive to hot sun or drying winds. When growing at the base of closely-set herbaceous plants such as clover, or in a shady wood, it appears to find its ideal conditions.

The fructification consists of an indefinitely effused, fairly thick, dense felt, not at all gelatinous or waxy, of a beautiful purplish or violet colour when at its best. The exact colour varies from light greyish-vinaceous, through livid brown and deep purplish-vinaceous, to dark Corinthian purple. The growing margin is byssoid and paler, while the hymenium is smooth, close but not waxy, and pruinose from the abundant hyaline spores and projecting sterigmata. With age, or in dry weather, the whole fungus becomes much paler in colour, tends to lose the purple tinge, and acquires a cinnamon-drab hue.

The basal hyphae are dark reddish-brown or purplish-brown in colour, septate at rather long intervals, branched, and 5–7 (–10)μ in diameter. Patouillard described occasional clamp-connections at the base of the basidia, but in none of the specimens seen by us has there been any trace of them, though occasional anastomoses of adjacent hyphae occur (Plate XI, fig. 11).

The hymenium consists mainly, if not entirely, of basidia, which are usually to be found in all stages (Plate XI, fig. 1). The young basidium is a cylindrical erect branch arising from one of the subhymenial hyphae. The basidia are hyaline and full of rather densely granular contents, whereby they stand out markedly from the basal and subhymenial hyphae, which tend to become empty at an early stage. The elongating apex of the basidium gradually becomes bent over in a characteristic crozier-like fashion (Plate XI, fig. 1), and soon afterwards transverse septa appear. The sterigmata arise one from each cell of

the basidium, and as a rule two or three only are found, rarely four (Plate XI, figs. 1, 2). They are subulate in form, and vary in length according to the depth of origin, in order to bring the spores above the surface level of the hymenium; the length may be from 10 to 15 or 35μ, and the width at the base 3·5–4μ. The spores are hyaline, ovate, elliptic oblong, or usually somewhat reniform, with practically no apiculus, 10–12 (–15) × 6–7μ (Plate XI, fig. 3).

The cytology of *Helicobasidium* has not been worked out in detail, but such observations on nuclear behaviour as have been made from stained preparations have indicated that the fungus may be interesting in this respect.

The mycelium of *Helicobasidium*, as far as observed in the fructification, is binucleate, the two small nuclei occurring usually rather close together near the middle of each cell (Plate XI, fig. 7, and Plate XII, figs. 13, 14). In the very young basidium there appears to be a single larger fusion nucleus, which remains until the crozier form has been assumed (Plate XII, fig. 15). The stages of division of the fusion nucleus have not been followed, and it is possible that irregularities occur. The cells of the septate basidium, before the development of sterigmata, are uninucleate (Plate XII, fig. 16), but division of this nucleus apparently may occur at a very early stage. Sometimes distinctly one nucleus only has been seen in the sterigma, while the very young spore shows as yet no nucleus (Plate XII, fig. 17). In other cases two nuclei may be observed in the sterigma, or one in the sterigma and one in the young spore (Plate XII, figs. 18–20). The mature spore appears to be usually binucleate (Pl. XII, fig. 21). It is possible however that the nucleus occasionally does not divide before entering the spore, and that a uninucleate spore and mycelium may result.

Morphological comparison of the mycelia of *Helicobasidium purpureum* and of *Rhizoctonia Crocorum*.

At first, before any fresh material was available, a careful examination was made of herbarium specimens of *Helicobasidium* in order to compare more closely the mycelial characters of the fungus with those of *Rhizoctonia*. The hyphae of the two fungi were found to be so much alike that the authors decided that their hypothesis was well worth testing and to this end the cultures of *Rhizoctonia* were begun. Later observations made from fresh specimens of *Helicobasidium* have confirmed the resemblance as to mycelial characters.

The vegetative hyphae of *Helicobasidium* are purple-brown in colour, very even in diameter for long distances, thick-walled and rather rigid when old, and in the septation, mode of

branching, and absence of clamp-connections cannot be distinguished from the typical hyphae of *Rhizoctonia Crocorum* (cf. Plate XI, figs. 11 and 12). Further, short swollen cells such as occur in connection with the sclerotia of *Rhizoctonia*, as figured by Duggar (*l.c.* p. 418), have also been found occasionally in *Helicobasidium*, where the hyphae become closely aggregated. There is also a resemblance between the two fungi in the development of mycelial strands, which adhere closely to the roots or other structures bearing the fungus.

With the object of checking the resemblance in external form, various strains of *Rhizoctonia* and of the growth obtained in culture from spores of *Helicobasidium* have been stained for nuclei. The first strain of *Rhizoctonia* which was isolated, namely that from red clover, was found to have only one nucleus in each cell (Plate XI, fig. 9). On the other hand, strains from potato and sugar beet possess very distinctly two nuclei in each cell, placed usually towards the middle as in the subhymenial hyphae of *Helicobasidium* (Plate XI, fig. 10). There is no difference in the parasitism of these strains, as successful inoculations have been carried out with all three.

Coming now to *Helicobasidium*, growths from spores, though not from single spores, have been stained with the result that a similar variation in nuclear behaviour has been observed. The strains tested were particularly those used in inoculation experiments. Of five of these, three had only one nucleus per cell (Plate XI, fig. 7), one was regularly binucleate (Plate XI, fig. 8), as is the mycelium of *Helicobasidium* in nature, while in the fifth both uninucleate and binucleate cells were present. The significance of these nuclear differences is not at present understood, and the subject would probably repay more exact cytological investigation.

Spore Germination and Growth in Culture of *Helicobasidium purpureum*.

The spores of *H. purpureum* germinate readily in the presence of moisture, and at ordinary room temperatures will put out short germ-tubes within twenty-four hours (Plate XII, fig. 22). In the course of preliminary observations made in hanging drops, it soon became evident, however, that there are difficulties as to further growth. The cytoplasm and nuclei pass into the germ-tube, which continues to elongate very slowly (Plate XII, figs. 22–25). The cytoplasmic contents, however, do not increase in proportion, with the result that there is formed a long empty hypha from which the small amount of apical cytoplasm is cut off by successive transverse walls (Plate XI, fig. 4 and Plate XII, fig. 23). This apparently starved form of

development is particularly marked in sterile water and on Dox's agar, the two media which were used for hanging drops, and most of the spores started on such media sooner or later die out without producing colonies. At the time the cultural experiments with *Helicobasidium* were started the authors had no experience as to suitable media for the growth of *Rhizoctonia*, hence it was necessary to try as many media as possible, both liquid and solid. On all those tried germination was found to be as described, always with the cytoplasm only at the growing apex of an otherwise empty hypha. There were however differences in the degree of further development according to the nature of the medium, and especially according to the relative thickness of sowings of the spores. It was soon noticed that isolated spores were particularly liable to fail (Plate XI, fig. 4), whereas the spores lying close together in a heavy deposit soon began to develop branches from the original germ-tube, and seemed to have better prospects of survival (Plate XI, figs. 5 and 6). For this reason the first stock cultures in 1923 were started from mass deposits of spores, and no attempt was then made to obtain single-spore growths. In some cases small portions of the hymenium were attached to the lids of Petri dishes in such a way that the liberated spores would fall on to the surface of the solid nutrient agar or gelatine. In other cases the spores were collected in moist chambers on clean sterilised glass slips, then suspended in sterile water, and drops of the suspension were spread on the surface of similar solid media. The spore deposits thus obtained were examined microscopically and appeared to be free from any obvious contaminations.

From plates started in this way very slow and apparently pure growth was obtained on several media, most readily on such media as malt extract agar, malt and meat extract agar or gelatine, prune agar, etc. Slight growth occurred on some other media, soil extract agar, Waksman's modified egg albumen agar, etc., but the first mentioned were found to be most suitable and have been used in all subsequent work with spores.

One of the difficulties in dealing with this organism has been its extremely slow rate of growth. In heavy spore deposits, the first visible indication of growth is seen in about four to six days at favourable temperatures, in the form of a slight purplish discolouration of the medium. In about ten days small colonies just visible to the eye are established. With isolated spores growth is much slower. In ten to fourteen days, at room temperatures, such spores may produce only two or three branches from the original germ-tube, while colonies are barely visible to the eye even after a month. If the cultures are incubated at 25° C. growth is a little more rapid. All cultures are charac-

terised by the development of an intense vinaceous colour in the substratum, accompanied usually by the precipitation of small rhomboidal crystals. The aerial mycelium is at first whitish to pinkish lilac. In a few cases it soon assumes more or less of the reddish brown or purplish colour which is characteristic of *Rhizoctonia*, the purple tinge being particularly noticeable on the more acid media such as prune agar. In the majority of cases however the aerial growth remains for a long time pale, and in such cultures there frequently appear in about a month small raised tubercles, which eventually become pustules of conidia of the type which is characteristic of the genus *Tuberculina* (Plate XII, fig. 26).

Most of the known species of *Tuberculina* are found associated with rust fungi, and have been regarded as parasites of the rusts. Hence, when conidia of this type appeared in the first multiple-spore cultures, it was thought probable that they belonged to an intruder, although no trace of such a fungus had been seen in any of the material used for making the spore-deposits. Unfortunately, by the time this difficulty arose it was too late to obtain further fresh material of *Helicobasidium*, and an effort was therefore made to separate what seemed to be two organisms by means of hyphal characters. In some of the cultures there was a radiating marginal zone of darker purplish hyphae, growing closely adpressed to the agar, which were morphologically very like those of *Rhizoctonia*. In other cultures there appeared after a time erumpent, dark purplish, compact masses of hyphae, almost sclerotium-like in appearance (Plate XIV, fig. 36). Such cultures gave the impression of being mixed growths, and it was thought that the darker hyphae must belong to the true *Helicobasidium*. It was not found possible to cut off single hypha tips, but by plating out teased-out portions of the compact masses, growth was obtained in two cases from what appeared to be single hyphal fragments. These two strains (*B* and *C*), when grown further, developed only the dark hyphae, and in fact acquired an appearance similar to that of various strains of *Rhizoctonia*, with no further development of conidia on any medium. They will be mentioned again in connection with inoculation experiments.

At the same time the conidia were plated out, and a few cultures from single conidia were transferred to tubes of malt and meat-extract agar. The further development of these single-spore cultures was surprising, in that they, also, developed at once the characteristic purplish brown mycelium, and remained continuously dark-coloured and quite sterile.

In the spring of 1925 fresh material of *Helicobasidium* was obtained, this time associated with root-rot in *Urtica dioica*.

Further specimens from the same locality were sent in April of 1926. Having now some experience as to suitable media for development of the fungus, the authors started plates in the hope of obtaining growth from single spores. Even on the most favourable media there seems to be always a tendency for many of the more isolated spores to die out after making very little growth. Development from the less isolated spores is more certain, but when several spores have germinated fairly close together, the isolation of guaranteed single-spore growths becomes difficult on account of the curious method of germination already described, with formation of a long (up to 2 mm. or more), wandering, empty tube which becomes almost invisible. Numerous moderately separated spores were transferred to fresh plates as soon as growth seemed promising, and from these a number of practically certain single-spore cultures were obtained.

Cultures on malt agar from single spores have shown variations equally as puzzling as those which originated from mass spore-deposits. The great majority at first produced pale-coloured aerial mycelium, and rather compact, lumpy growth. One or two strains, however, became more or less brownish almost at once, and developed more spreading and closely adpressed hyphae. Many of the former in the 1925 isolations produced conidia, and of the 1926 isolations all the single-spore strains tested produced conidia abundantly when transferred to potato plugs (Plate XIV, fig. 37). Hence there is no doubt that the conidia really belong to the *Helicobasidium* and do not, as was first thought, indicate an impurity. There seems to be an undoubted tendency for the power to produce conidia to be lost after a long period *in vitro*. Cultures which in 1923 were producing *Tuberculina* pustules abundantly now form very few, if any, conidia. Similarly, some of the subcultures from 1925 isolations have now ceased to produce conidia, and one at least has a luxuriant reddish brown growth of aerial hyphae not unlike that of a strain of *Rhizoctonia* from alfalfa.

Description of conidial form, and comparison with other species of *Tuberculina*.

The first indication of the formation of conidia in cultures is the development of small tubercles towards the centre of the colony. Sometimes these occur irregularly, but more often they are arranged in a ring, giving a rosette-like effect. The middle of each tubercle becomes slightly indented and acquires a violet colour and a smooth surface which contrasts sharply with the pale hyphal margin. As the conidia are formed the colour becomes slightly more reddish, the final tint of the conidia in

mass being from vinaceous-fawn to vinaceous-russet. When the conidia are developed abundantly, as on potato plugs, they fall away from the acervuli, and the base and inner walls of the culture tubes become covered with the dusty, vinaceous powder.

The structure of each acervulus is that of the genus *Tuberculina*. In the early stages the conidiophores line the base of a slight depression, but eventually they grow out to form a convex sorus of the usual Tuberculariaceous type. The conidiophores are erect, unbranched, unseptate except at the base, very closely crowded, obclavate, or, after development of the first conidium, slightly pointed at the apex, about 25–35 × 4·5–5·5μ (Plate XII, fig. 26). The conidia are usually globose, 10–16μ in diameter, but may sometimes be elliptical or ovate, 10–18 × 9–15μ (Plate XII, figs. 26, 27). Each conidium has two nuclei, which on germination pass with the cytoplasm into the germ-tube (Plate XII, figs. 28, 30). As in the case of the basidiospores, the cytoplasm follows the growing apex and a long empty tube is left behind (Plate XII, fig. 30). The regular *Tuberculina* pustules just described are typical of comparatively recent isolations. Along with them there occur also conidia borne apparently on ends of ordinary projecting hyphae, and these latter tend to be deeper in colour and more variable in shape. They suggest in fact chlamydospores. In strains which have been growing for a long period *in vitro* the second type of conidium is more abundant (Plate XII, fig. 29).

Comparison with other species of *Tuberculina* leaves no doubt as to the affinities of this conidial form. In habit and in the constant presence of two nuclei the species resembles most closely *T. persicina* Ditm. as described and figured by Cornu (13), Sappin-Trouffy (14) and others. It differs from that species, however, in its larger and sometimes elliptical or ovate spores. The method of germination of the conidia is similar to that described by Cornu (13) for *T. persicina*, and by Tubeuf (15) and Lechmere (16) for *T. maxima*. The latter species also has large conidia, but its mycelium and spores are constantly uninucleate, as observed by Lechmere (16) and verified by us.

With regard to the conidial form already mentioned, which was described by Patouillard as occurring in specimens of *Helicobasidium* from Nice, Patouillard's figure (Tab. Anal. no. 561) represents an arrangement of erect, unseptate conidiophores arising from the coloured basal hyphae, which bears a slight resemblance to the acervulus found in culture. The conidiophores, however, are figured with a much more drawn-out apex, and the conidia are long-elliptic, not at all globose. Unfortunately the specimens of *H. purpureum* var. *Barlae* which are in the Kew Herbarium show no trace of conidia, hence it

has not been possible to check Patouillard's description. None of the material of *Helicobasidium* we have examined has ever shown any development of conidia in nature.

Comparison of the growth in pure culture of *Helicobasidium* and *Rhizoctonia*.

During the period of three and a half years that the cultural work with *Helicobasidium* has been in progress, opportunity has arisen to grow also several strains of *Rhizoctonia* for comparison. In addition to the strain from red clover, whose growth in culture has already been described (5), we have since isolated the fungus from infection cushions formed on potato, sugar beet, mangold, and stinging nettle (*Urtica dioica*)—in the latter case associated with *Helicobasidium*. We have also received from Dr Kotila of Michigan a strain isolated by him from alfalfa, and from the Central Bureau for Cultures at Baarn a strain isolated by Wollenweber from *Beta vulgaris* (variety not stated).

These seven strains, while agreeing in general macroscopic and microscopic characters, such as colour, size and septation of hyphae, etc., yet show considerable variation amongst themselves in cultural characters when grown on the same medium and under the same conditions. Thus on malt extract agar, the medium which has been used constantly in the more recent work, the alfalfa strain, as one extreme type, has always given more luxuriant and more rapid growth than any of the others, and forms a characteristic radiating mycelium which spreads round the sides of the tube. This strain is at first very pale, and always shows a pale marginal growing zone. The potato strain also gives fairly luxuriant aerial growth, but less pale at first, more uniform in colour, and without the striking radiating growth. The strain from red clover is also uniform in colour, and produces less aerial mycelium, most of the growth being closely adpressed to the medium. The strain from *Beta vulgaris* has a general appearance somewhat like the clover strain, but has a tendency to form large, sclerotium-like lumps in old cultures, while that from sugar beet gives also lumpy growth with greater tendency to violet coloration than most forms. The mangold strain comes at the other extreme of the series, the growth being very compact and irregularly lumpy, with little or no spreading mycelium. The fungus isolated from roots of *Urtica* has been, until recently, always paler and slower in growth than any of the others, and has formed scattered lumpy colonies much like the early isolations of *Helicobasidium* from spores. A comparatively recent sub-culture, however, has developed the more normal brownish

spreading mycelium, and all subsequent transfers from this tube have retained this character.

The various strains also vary somewhat when grown on different media, and sometimes at different periods, for no apparent reason. Thus the clover strain on potato plugs sometimes remains dark, but occasionally gives at first a quite pale growth.

The variation in macroscopic appearance in cultures of *Rhizoctonia* is paralleled closely by similar variation observed in the cultures made from spore deposits of *Helicobasidium*. As already noted, the *Rhizoctonia* from *Urtica* resembles most closely the pale-coloured cultures which form the majority in first isolations from spores. The fact that a brown strain has appeared in subcultures from this is exactly similar to the early experience with subcultures from *Helicobasidium*, when growths of such different appearance were obtained that we were for a long time convinced that the original cultures must have been mixed. A further interesting parallel is found in the presence of conidia. When it was noticed that potato plugs favoured the development of conidia, the strains of *Rhizoctonia* were also transferred to that substratum. While most of them gave nothing but the usual sterile growth, the *Urtica* strain developed *Tuberculina* conidia, with typical pustules such as occur in many *Helicobasidium* strains. Further, the mangold strain (which has been proved to cause *Rhizoctonia* root-rot) gave similar conidia, though in this case they were not developed in regular pustules, but resembled rather the conidia of *Helicobasidium* strains that have been grown in artificial culture for a long period (Plate XII, fig. 31).

Another point of resemblance appeared when strain *B* of *Helicobasidium* was grown in Petri dishes and allowed to get rather dry. Here sclerotium-like bodies developed exactly resembling those of the clover *Rhizoctonia* when grown under similar conditions ((5), p. 299).

The temperature relations of the two fungi appear to be alike. The details have not been worked out for *Helicobasidium* as for *Rhizoctonia* (5), but its optimum temperature for growth appears to lie similarly in the neighbourhood of 25° C.

Inoculation Experiments.

Except for the conidia above described as occurring in two cases, no strain of *Rhizoctonia* has yet produced any form of fructification in culture, and there seems to be little hope of obtaining the perfect stage under artificial conditions. Hence the only method of proving a connection between these two

fungi would seem to be that of producing the typical root-rot by inoculation with pure cultures of *Helicobasidium*.

To this end a large number of inoculations of living plants, chiefly various clovers, and occasionally carrot, have been carried out with strains derived from spore cultures of *Helicobasidium*, and at the same time parallel inoculations have been made with the strains of *Rhizoctonia* available. In all cases the plants have been grown in large pots (8″ to 10″). In the first experiments the soil used was the ordinary partially sterilised, potting soil as used at Kew; in later work the pots and soil were sterilised in the autoclave. In working with a fungus such as this, which grows only very slowly in the soil and does not readily produce spores, the danger of accidental contamination is very slight, but as a precaution control pots in adequate numbers have always been used to check results.

The fungus *Rhizoctonia Crocorum* does not appear to be a very virulent parasite under ordinary English conditions. The few inoculations made in open ground have failed, and when diseased clovers have been transplanted to fresh uninfected ground they have recovered and there has been no further spread of the fungus on their roots. Inoculations made in pots have frequently succeeded, but there have also been failures, and the right conditions for infection are not altogether understood. There is some indication that infection takes place more readily in a sandy, well-aerated soil, provided sufficient moisture is present, than in heavy soils. There is also some indication from the results obtained by the authors that after growth for a long period *in vitro* on a medium such as meat-malt-extract agar, on which the fungus makes its most abundant development, the *Rhizoctonia* may lose its virulence. Successful inoculations have, however, been obtained with cultures of both *Helicobasidium* and *Rhizoctonia*.

Of the strains of *Rhizoctonia* isolated from infection cushions on diseased roots, that from red clover has produced root-rot with infection cushions on carrot and on various clovers. The strain from sugar beet has also infected carrot and clovers, including lucerne or alfalfa; while those from potato and mangold have produced root-rot in various clovers. Infection with the clover strain was at first very vigorous, but became less so after the cultures had been maintained for two years. The mangold strain has not given a very high proportion of infections. No result has as yet been obtained from inoculations with the strains isolated by Kotila and Wollenweber, nor with the strain we isolated from roots of *Urtica*.

Successful inoculations with cultures derived from spores of *Helicobasidium* have been less frequent. Three strains, all of

which originated from the first specimens, associated with red clover, have produced the typical symptoms of Violet Root-Rot in clovers and carrot. One result was also obtained early in the work with a fourth strain (*C*), but as the plants used in that experiment had been transplanted from a field, thought to be free from infection but not certainly so, there is some doubt as to whether the infection was due to the inoculation. No other inoculations with *C* have given positive results. In 1925 a very large number of pots were inoculated with strains of both multiple and single-spore origin, derived from the *Helicobasidium* associated with *Urtica*, but none of these strains has so far given any infection. It is just possible that the *Urtica* strain may not be infective to the host plants used in these experiments, but the matter will be discussed further in the next section.

The history of the strains of *Helicobasidium* which have given positive results is as follows:

A. Originated from a spore deposit made in April 1923, which was transferred directly to a tube of malt agar on April 19th. This culture produced the compact purple growth described above, portions of which were teased out and plated. Promising-looking hyphae from these growths were transferred to malt agar on June 18th, 1923. A tube used for inoculation on March 24th, 1924, gave no result, but a malt-meat extract subculture from it made on the same day gave positive results when used on April 15th, 1924.

B. The hymenium used for making the original spore deposit on Dox's agar on April 10th, 1923, was growing on oat stubble which was intermixed with affected red clover.

Transfers were made as follows: April 16th, potato agar; May 12th, prune agar. This tube developed the purple compact growths described, fragments of which were plated out on June 3rd (malt agar). A growth which appeared to be coming from a single hyphal fragment was transferred to a tube of malt-meat-extract agar on June 28th, 1923. Subcultures from this tube were those afterwards used for inoculations.

C. The early history of this strain is the same as that of *B*. From the plate made on June 3rd a growth which had certainly originated from a small fragment of a single hypha was transferred to a tube of Jardox gelatine on July 2nd, 1923. Subcultures from this were those subsequently used for inoculations and called *C*.

F. A spore deposit was made on April 14th, 1923, and transferred to spinach agar. Subcultures from this to malt agar were made on May 4th and on June 14th. The cultures had remained reddish brown from the beginning and had produced

no conidia, hence no plating out had been considered necessary. The tube of June 14th and subsequent subcultures were used in inoculation experiments.

The table on p. 135 sets out the method of treatment and results in the successful experiments made with these strains.

Discussion of Results.

The important fact which emerges from the work just recorded is that there is a very intimate association between the Basidiomycete *Helicobasidium purpureum* and the root parasite known as *Rhizoctonia Crocorum*, whatever the nature of the relationship may be. Root-rot, characterised by the presence of the "corps miliaires" or infection cushions which are typical of *Rhizoctonia Crocorum*, has been found in every locality investigated where *Helicobasidium* has been found. Further, the association is so close that in two strains of *Rhizoctonia* isolated in the usual way from infection cushions, conidia similar to those obtained from *Helicobasidium* have been produced in cultures.

The supposition that *Helicobasidium* represents the perfect stage of *R. Crocorum* is supported by these facts of intimate association, by the morphological characters of the hyphae of the two fungi, by their similar rates of growth and temperature relations, and by the results of inoculation of living roots by certain strains derived from spore-cultures of *Helicobasidium*.

The last point is the most important evidence in favour of direct genetic connection between *Helicobasidium* and *Rhizoctonia*. The experiments were carried out with careful controls, and except in the first series of pots the soil used was thoroughly sterilised in the autoclave. These precautions, and the fact that it has been always the same strains, *A*, *B*, and *F*, which have given infections, though with some evidence of declining virulence in the course of time, seem to preclude the possibility of accidental infection. It is true that the results are open to the objection that the strains used were derived from original mass spore deposits, and not from single spores; but care was taken to observe that the spores shed were free from any obvious contaminations, and repeated examination of the specimens of *Helicobasidium* used has revealed no other spore-form than the basidiospores of this fungus.

At the same time, the rather widely different appearance of many of the primary spore isolations of *Helicobasidium* from most of the vegetative isolations of *Rhizoctonia*, and the variable behaviour of cultures, does seem to indicate a possibility that *Helicobasidium* may be another species living in close association with *Rhizoctonia*, so close that separation by

Table showing details of successful inoculations with strains of Helicobasidium.

	Plant	Treatment	Date of Inoculation	Strain	Result	Remarks
1	Red clover	Soil from Kew stock partially sterilised, seed sown 5. VII. 23, transplanted when plants had several leaves.	3. IX. 23, 2. XI. 23	*B*	+ (11. IV. 24)	4 good infections with infection cushions, 2 doubtful, out of total 10
2	Carrot	Soil from Kew stock partially sterilised, seed sown 5. VII. 23, transplanted when plants had several leaves	21. IX. 23, 2. XI. 23	*B*	+ (16. III. 24)	4 plants with infection cushions out of 10
3	Carrot	Same soil as in 1, not sterilised	Not reinoculated	*B*	+ (10. IX. 24)	1 plant badly rotted, 16 clean
4	Mixed clovers	Pots autoclaved, soil inoculated when seed sown	15. IV. 24	*F*	+ (17. IX. 24)	Infection on 3 plants out of 6
5	Alsike	Pots autoclaved, seedlings transplanted from old control pot of 1924	28. VI. 25	*F*	+ (13. X. 25)	5 plants out of 9 infected; soil rather sandy
6	Carrot	Pot autoclaved, seed sown 17. IV. 25 in old control pot of 1924, transplanted 14. V. 25	28. VI. 25	*B*	+ (13. X. 25)	1 plant infected out of 5
7	Mixed clovers	Plants transplanted from field	14. IV. 24	*C*	+ (18. XI. 25)	Few plants infected 1925; doubtful case, long period, and original soil not sterilised
8	Alsike	Soil autoclaved, seeds sown in autoclaved soil and seedlings transplanted to 2 small pots	28. VI. 25	*A*	?+ (Oct. 1925)	No infection cushions formed, but one plant showed slight weft of hyphae on root
9	Mixed clovers	Soil autoclaved, inoculated when seed sown	15. IV. 24	*A*	+ (5. I. 25)	50 % of numerous plants in pot infected; tap-root destroyed in some instances

ordinary cultural methods is difficult or impossible. It has been already described how the appearance of *Tuberculina* conidia in their first isolations led the authors to suppose that these were mixed growths. There is no doubt that this conviction caused progress to be slower than it might otherwise have been. With the successful development of single-spore growths, the conidial form has been shown to belong to *Helicobasidium*. There still remains the difficulty, however, that five out of the seven strains of *Rhizoctonia* studied have never produced conidia, and that successful inoculations with *Helicobasidium* have been much less frequent than those with *Rhizoctonia*.

If infection could be obtained with a single-spore culture the case would be proven. Unfortunately the only single-spore cultures we have at present are those derived from the fungus associated with *Urtica*, and as already noted neither the *Rhizoctonia* nor any of the spore strains isolated from this host has as yet given any infection. It is possible that this particular strain is not pathogenic to the plants used in our experiments. On the other hand, such cross-inoculations as have been carried out with strains of *Rhizoctonia* from different host-plants have tended to disprove the existence of any great biologic specialisation in this fungus.

It is obvious that one of the most pressing needs is for more exact information as to the conditions under which *Rhizoctonia* will infect living roots. There have been many failures even in experiments with known infective strains; hence negative results have not the same importance they would have in the case of a more virulent parasite.

Another, as yet unexplained, complication is the extraordinary variation in the appearance of cultures from time to time. There are two main types of growth; one is pale-coloured, compact and lumpy, and this usually produces conidia on suitable media; the other consists of spreading purplish brown hyphae which remain dark-coloured and never produce conidia, but may sometimes form sclerotium-like bodies. When subcultures are made from the dark mycelium they retain these characters and never again produce the pale form of growth, a phenomenon which is illustrated by the history of strains *A*, *B*, and *C* of *Helicobasidium* and by the recent appearance of a dark-coloured, apparently permanently sterile strain in a subculture from the conidia-producing *Rhizoctonia* from *Urtica*.

It is tempting to suppose that *Helicobasidium* is an extremely plastic organism, from which mutants may readily arise. Some support for such a view is provided by the fact that in Petri-dish cultures, both of *Helicobasidium* and of *Rhizoctonia*, a curious sectoring effect is sometimes observed. Sectors of an otherwise

pale-coloured colony may develop the deeper brownish colour; or the hyphae of one sector may suddenly begin to grow much more rapidly than the rest of the colony, so that a markedly lobed outline is produced in place of the previous regular circular shape.

If the explanation of the growth differences observed is to be found in such a tendency to variation (or perhaps mutation), it is conceivable that the pathogenicity of the fungus is subject to similar variation. If that is so, the non-success of so many inoculations made with spore cultures may be due to the fact that the majority of strains are but feebly if at all parasitic, whereas occasionally a more virulent form appears which will produce *Rhizoctonia* root-rot on a suitable host plant. The fact mentioned above, that the mangold strain of *Rhizoctonia* (which produces conidia) is rather less virulently parasitic than a quite sterile form like that from clover, agrees with the results of experiments with *Helicobasidium*, where conidia-bearing strains have produced no infection, and all successful inoculations have been achieved with the derived sterile strains.

From the taxonomic point of view a further interesting question is opened up by the discovery that *Helicobasidium* possesses a conidial stage which morphologically and cytologically is indistinguishable from certain species of the genus *Tuberculina*. The known species of *Tuberculina* are usually found in association with rust fungi, on which they have been supposed to be parasitic, and they have not hitherto been genetically connected with any higher form. In this connection there has arisen an interesting coincidence, which may, or may not, be of significance. In searching through the literature the authors discovered the description of *Rhizoctonia Menthae* B. and Br. (17), in which mention is made of globose conidia. Berkeley and Broome referred the fungus to the genus *Rhizoctonia* on account of the presence of sclerotia, and a weft of violet hyphae resembling those of *R. violacea* (*R. Crocorum*). On examination of the type specimen of *R. Menthae* in the British Museum, it was found that the conidia described are those of a *Tuberculina*, which has practically replaced the aecidia of *Puccinia Menthae*, only a few aecidiospores remaining to prove the existence of the usual association.

Summary.

1. Fertile *Helicobasidium purpureum* has been found in very close association with root-rot characterised by infection cushions of *Rhizoctonia Crocorum* in distinct localities, on (*a*) red clover, (*b*) *Mercurialis perennis*, (*c*) *Urtica dioica*.

2. In order to test the possible connection of the two fungi, they have been studied morphologically, culturally, and as to pathogenicity.

3. Morphologically the hyphae of *Helicobasidium* are exactly similar to those of *Rhizoctonia*, having the same type of branching, septation, and absence of clamp connections. They also resemble one another in nuclear characters, both fungi having sometimes one but more often two nuclei per cell.

4. Seven strains of *Rhizoctonia Crocorum* have been compared with numerous spore isolations of *Helicobasidium* as to cultural characters. Both fungi show considerable variation in colour and type of growth. Conidia belonging to the genus *Tuberculina* are frequently produced in cultures of *Helicobasidium*, and similar conidia have been found in strains of *Rhizoctonia* isolated from *Urtica* and from mangold. In cultures of *Helicobasidium* which originated from multiple spores there sometimes develop in subcultures strains which acquire the dark colour characteristic of the sterile *Rhizoctonia* strains, and which remain henceforth sterile. A similar variation has arisen in the *Rhizoctonia* isolated from *Urtica*, which at first produced only pale growth, with a tendency to form conidia.

5. Successful inoculations, with the production of typical root-rot, have been obtained with four strains of *Rhizoctonia*, and with three of the dark-coloured strains derived from *Helicobasidium* spore cultures. The host plants used were various legumes and carrot. In every case precautions were taken to exclude the possibility of accidental infection, and adequate controls were used.

6. The strains of *Helicobasidium* which have proved infective all originated from specimens associated with red clover. None of the strains from *Urtica*, nor the *Rhizoctonia* isolated from *Urtica*, has up to the present produced any infection on clovers or on carrot. Other strains of *Rhizoctonia*, however, have not given evidence of any specialisation in parasitism.

7. The bearing of the observations made is discussed. While there have been inconsistencies in behaviour, it is possible that these are due to the fact that the organism is very variable, and that not all the strains are equally parasitic. It has also to be borne in mind that practically nothing is known as to the conditions for infection with *Rhizoctonia Crocorum*.

The balance of the evidence is considered to favour the view that *Helicobasidium purpureum* (Tul.) Pat. is the perfect stage of *Rhizoctonia Crocorum* (Pers.) DC.

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DESCRIPTION OF PLATES

Plate XI.

Fig. 1. *Helicobasidium purpureum*. Vertical section of sporophore showing hymenium and part of subhymenial tissue. × 450.

Fig. 2. *H. purpureum*. Two basidia. × 500.

Fig. 3. *H. purpureum*. Spores. × 500.

Fig. 4. *H. purpureum*. Germination of an isolated spore, showing poor growth and gradual dying of hyphae, with possible origin of two colonies. The dotted portions contain protoplasm, the remaining hyphae being empty.

Figs. 5 and 6. *H. purpureum*. Late germination of spores in a mass deposit on meat-malt-extract agar, showing favourable influence of the presence of other colonies. × about 450.

Fig. 7. *H. purpureum*. Hyphae from strain *F* in pure culture, showing two nuclei in each cell. × 500.

Fig. 8. *H. purpureum*. Hypha from strain *C* in pure culture, showing one nucleus per cell. × 500.

Fig. 9. *Rhizoctonia Crocorum.* Hypha from red clover strain in pure culture, showing one nucleus per cell. × 500.

Fig. 10. *R. Crocorum.* Hypha from sugar beet strain in pure culture, showing two nuclei in each cell. × 500.

Fig. 11. *H. purpureum.* Hyphae on stem of *Urtica dioica.* Drawn from specimen in Jaap, Fung. Sel. Exs. No. 389. × 500.

Fig. 12. *R. Crocorum.* Surface hyphae from potato. × 500.

Plate XII.

Figs. 13–20. Successive stages in the development of basidium and spores. × 800. Fig. 13. Terminal cell of hypha with two nuclei. Fig. 14. Beginning of fusion. Fig. 15. Young basidium with large fusion nucleus. Fig. 16. Basidium after completion of divisions of fusion nucleus. Fig. 17. Development of sterigmata and spores. Fig. 18. Division of nucleus after entering sterigma. Fig. 19. Passage of first nucleus into spore. Fig. 20. Second nucleus entering spore.

Fig. 21. *H. purpureum.* Binucleate basidiospores. × 800.

Fig. 22. *H. purpureum.* Germination of basidiospores. × 800.

Fig. 23. *H. purpureum.* Germinating basidiospore, showing passage of cytoplasm to extreme tip of germ tube. × 800.

Figs. 24, 25. *H. purpureum.* Development of first branches of germ tube from basidiospore, showing binucleate condition. In Fig. 25 the nuclei have divided but a wall has not yet been formed. × 800.

Fig. 26. *H. purpureum. Tuberculina* conidial form as developed in pure culture, strain from red clover: (*a*) portion of conidial layer of pustule, (*b*) isolated conidiophores. × 500.

Fig. 27. *H. purpureum.* Conidia from pure culture, *Urtica* strain. × 500.

Fig. 28. *H. purpureum.* Conidia, showing two nuclei. × 800.

Fig. 29. *H. purpureum.* Conidia formed in old cultures, not in definite pustules (? chlamydospores). *Urtica* strain. × 500.

Fig. 30. *H. purpureum.* Germination of *Tuberculina* conidia. × about 350.

Fig. 31. *R. Crocorum.* Conidia developed in culture of mangold strain on potato plug. × 500.

Plate XIII.

Fig. 32. *Red clover.* Showing fructification of *Helicobasidium purpureum* on petioles and stems at ground level, and infection cushions of *Rhizoctonia Crocorum* on the tap-root. Natural size.

Plate XIV.

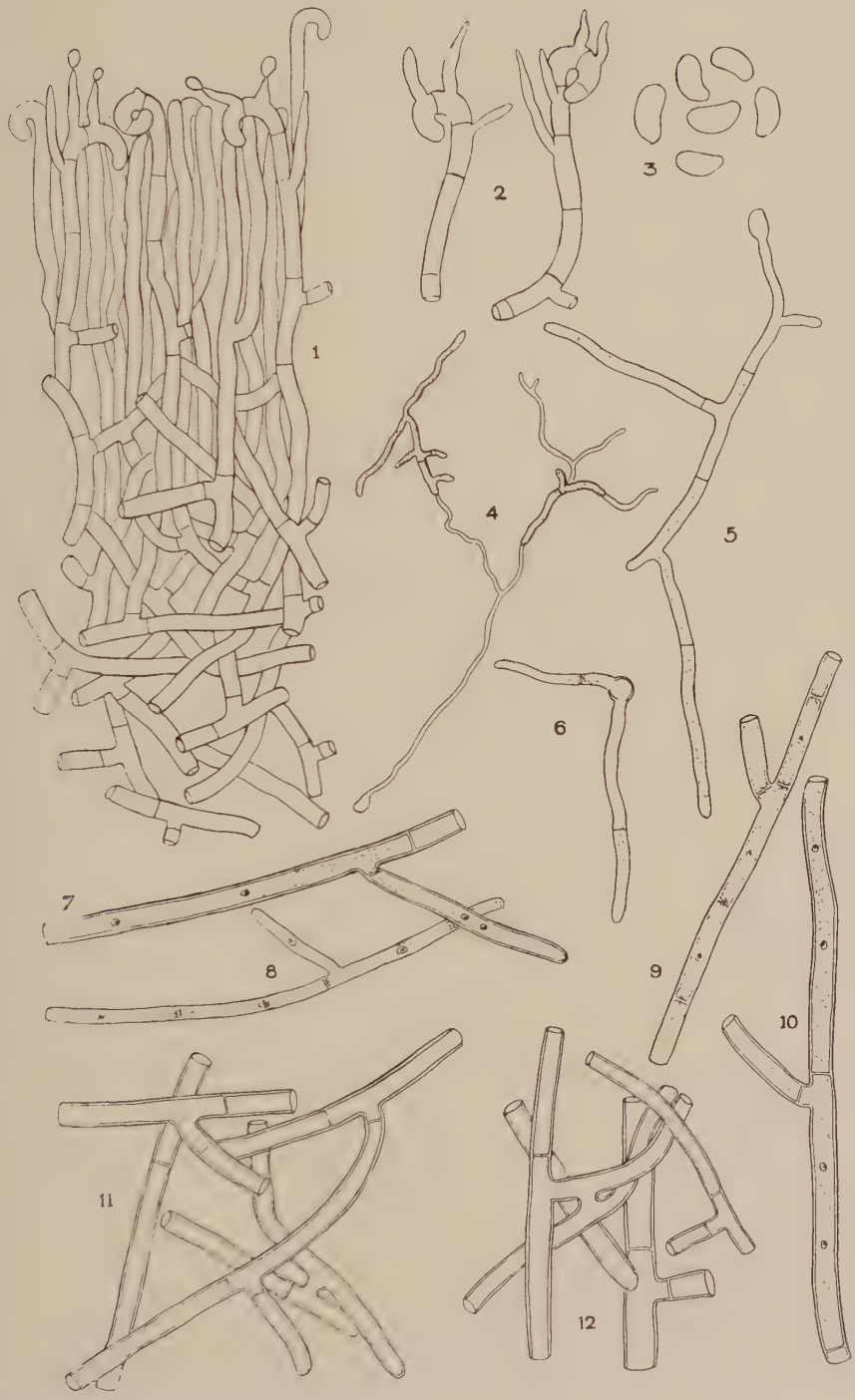
Fig. 33. *Mercurialis perennis.* Fallen ash twig on left covered with superficial felted mycelium; small root in centre showing numerous infection cushions of *R. Crocorum.*

Fig. 34. Portion of an underground runner of *Mercurialis perennis* showing rotted cortex with infection cushions of *R. Crocorum.*

Fig. 35. *Urtica dioica.* Showing fructification of *Helicobasidium purpureum* on stem above ground, and infection cushions of *R. Crocorum* on roots and underground runners.

Fig. 36. *Helicobasidium purpureum* (red clover strain). First isolations from spores, showing two kinds of growth.

Fig. 37. *Helicobasidium purpureum* (*Urtica* strain). Single-spore culture on potato plug, showing numerous pustules of conidia of the *Tuberculina* type.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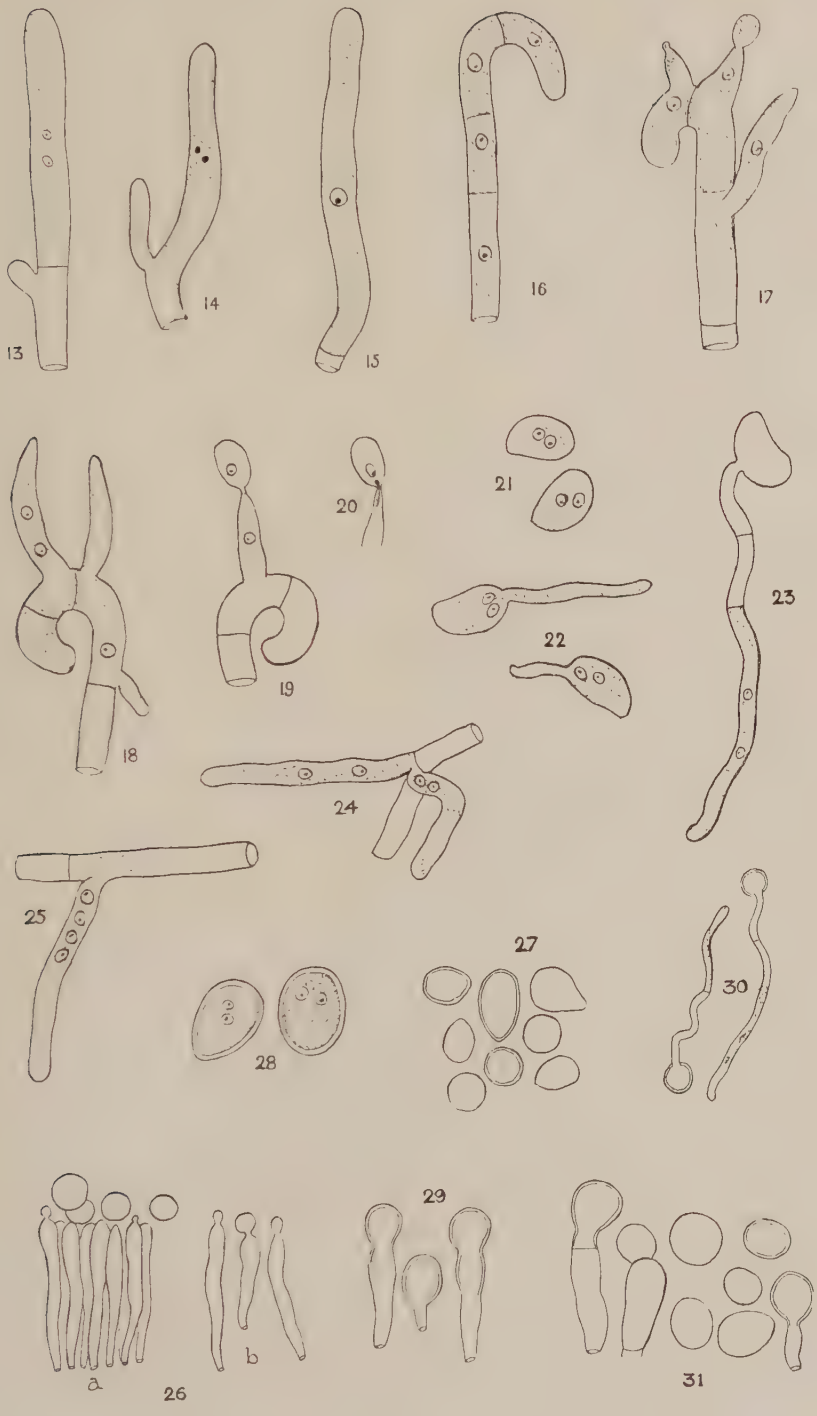
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MACROPHOMINA PHASEOLI (MAUBL.) COMB. NOV. THE PYCNIDIAL STAGE OF RHIZOCTONIA BATATICOLA (TAUB.) BUTL.

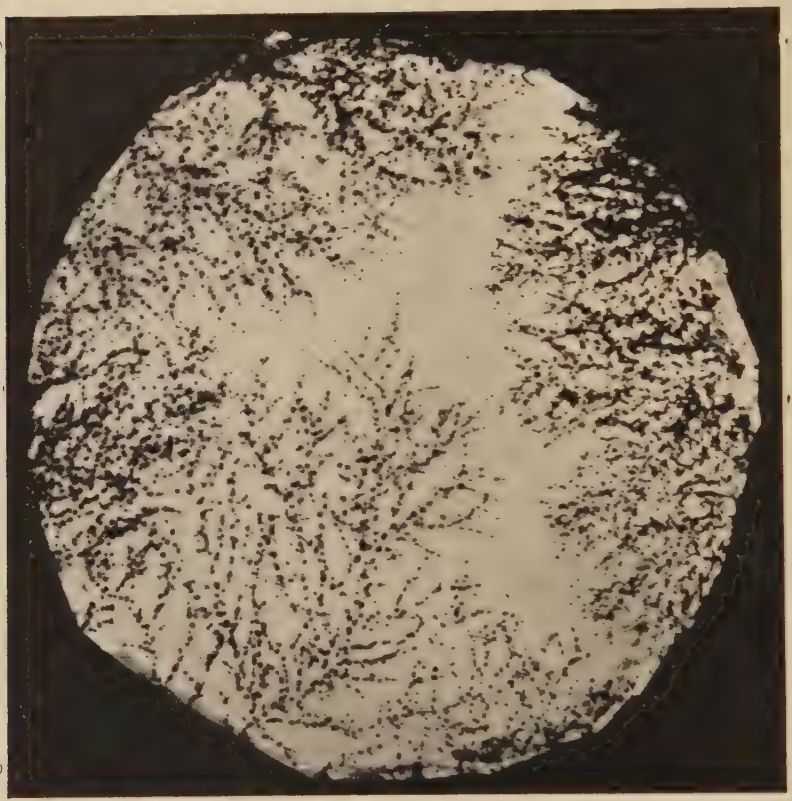
(With 1 Text-fig.)

By S. F. Ashby, Mycologist, Imperial Bureau of Mycology.

In 1912 Shaw(1) described an apparently sterile fungus with minute black sclerotia as the cause of a seedling disease of jute, cowpeas, groundnuts and cotton at Pusa, India. He referred it erroneously to *Rhizoctonia Solani* Kühn which is now regarded as the sterile stage of *Corticium Solani* (Prill. and Del.) Bourd. and Galz. Taubenhaus(4) in 1913 described a similar sclerotial form as the cause of a charcoal rot of the sweet potato in New Jersey, U.S.A. and named it *Sclerotium bataticola*. In 1915 Shaw and Ajrekar(2) listed twenty-one hosts of his *Rhizoctonia* in India, of which twenty were herbaceous. In 1924 Small(5) described a *Rhizoctonia* which developed black sclerotia of variable size and shape in the diseased roots of many woody plants in Uganda; he named it *Rhizoctonia lamellifera*. In 1925 Briton-Jones(8) gave the name *Rhizoctonia bataticola* (Taub.) Butl. to a sclerotium causing a root-rot of cotton, french beans and cowpeas in Egypt; this binomial was based on a comparison by Butler of pure cultures of the forms from India, Egypt and America which showed them to be identical. In 1926 Small(7) recognised the identity of his fungus with the forms from India, Egypt and America and abandoned the name *R. lamellifera*.

In 1916 Sawada(9) described a disease of jute (*Corchorus capsularis*) in Formosa caused by a pycnidial fungus which he named *Macrophoma Corchori*. In pure culture minute black sclerotia were developed which he thought might be immature pycnidia. In 1924 Shaw(3) published further studies on the *Rhizoctonia* disease of jute (*C. capsularis* and *C. olitorius*) in India, which he had first described in 1912, and found a *Macrophoma* constantly associated with the minute black sclerotia in the cortex. Pure cultures from single spores of the *Macrophoma* developed the sclerotial form. An exchange of cultures with Sawada resulted in agreement that the forms in India and Formosa were identical, and Shaw adopted the name *Macrophoma Corchori* Saw. for his fungus. Repeated isolations from single spores when inoculated on jute caused the sclerotial disease and the appearance of *Macrophoma* pycnidia in the lesions. Isolations from potato (*Solanum tuberosum*) and cotton when inoculated on jute also produced the sclerotial disease and

pycnidia. Cultures grown from single spores when inoculated on hosts other than jute gave rise to sclerotial disease but no pycnidia developed. Shaw concluded that the pycnidial form is restricted to jute. Exchange of cultures with Taubenhaus established the identity of the Indian and American forms, but when the American strain from sweet potato was inoculated on jute, although sclerotial disease resulted, no pycnidia formed.



Macrophoma Phaseoli; marginal growth showing sclerotia of three colonies developing from single spores out of pycnidia on bean stems from S. Carolina, U.S.A.; plate culture on Dox's agar, 5 days old at 24° C. × 5.

In 1925 Dr Small sent from Uganda to the Imperial Bureau of Mycology, roots and the lower parts of the stem of a plant of *Sesamum indicum* attacked by the sclerotial disease, and, later in the year, a dry fruit of sesame bearing pycnidia of a *Macrophoma* but no sclerotia, was received from Mr Snowden, Acting Mycologist in Uganda. Six months later the specimens were examined again and *Macrophoma* pycnidia identical with

those on the fruit and closely resembling *M. Corchori* were found scattered on the stem lesions caused by the sclerotial fungus. An attempt was then made to germinate spores from teased up pycnidia on the fruit; many were found to be viable and ten vegetations from single spores were secured and transferred to a modified Dox's agar medium*. After a few days at 26° C. the growths developed minute black sclerotia and each was found to be a pure culture of *Rhizoctonia bataticola*. It was evident that a *Macrophoma* formed part of the life cycle of the sclerotial fungus on sesame, and confirmation was obtained of Shaw's observations on the *Macrophoma* stage in India. There are at least two records of similar pycnidial forms on sesame in the East, one by Petrak (11) in 1923, who described *Macrophomina philippinensis* on sesame stems from the Philippines and the other by Sawada (10) in 1922 who named a *Macrophoma Sesami* on stems in Formosa. Through the courtesy of Dr Petrak, his type has been examined and found to agree in essentials with the form on sesame in Uganda; this he has also examined and confirmed its identity with his type. Sawada's description is in Japanese†, but his two figures of a section of the pycnidial wall showing conidiophores and of the spores suggest close similarity. Sawada's description of *M. Corchori* and Shaw's data cover the form from Uganda. A *Macrophoma* on leaves of *Corchorus* sp. from Dacca, Bengal (Herb. Crypt. Ind. Orient. No. 2293) has been examined and found to fit the descriptions of the form on the stems of jute in India and Formosa. The type of *Macrophoma Cajani* Syd. and Butl. (1916) (12) on living stems of pigeon-pea from Pusa (India) has been examined and is in close agreement with the *Macrophoma* on jute and sesame. Through the courtesy of Dr C. A. Ludwig specimens of bean stems (*Phaseolus vulgaris* L.) from South Carolina and Mississippi, bearing pycnidia of the *Macrophoma* type associated with minute black sclerotia, have been examined and proved to be alike. Eight vegetations developed from single spores were found to be pure cultures of *Rhizoctonia bataticola*, a proof that the sporing stage of that fungus occurs in the United States on beans. The disease on beans (13, 14) was only recently recognised in the United States, where it is known as *Macrophoma* stem-rot or ashy stem blight, the associated pycnidial fungus being referred to *Macrophoma Phaseoli* Maubl. which was described in 1905 (15) on stems of *Phaseolus vulgaris* from Tunis. The pycnidia and spores of the American fungus appear identical with those on jute and sesame and conform to

* Potassium nitrate 2·0: magnesium sulphate (cryst.) 0·5, potassium phosphate (K_2HPO_4) 1·0, cane-sugar 15·0, ferric chloride 1 drop, agar 15·0, water (dist.) 1000.

† See footnote p. 145.

the original description of *M. Phaseoli*. The sclerotial disease of *Phaseolus* spp. has been observed also in India, Egypt, Uganda and Ceylon, but has not been recorded in association with a pycnidial form which has doubtless been overlooked.

Petrak's and Sydow and Butler's types do not show definite indications of sclerotia in the tissues although the intra-matrical mycelium is similar to that of *R. bataticola*. Sclerotia were not found in the wall of the fruit of sesame from Uganda but developed abundantly in cultures from spores in the pycnidia, and sclerotia were not formed in the leaves of jute. It would seem that the *Macrophoma* stage may appear independently on aerial parts of some hosts, and its connection with the sclerotial disease on the same host or on other hosts can be easily overlooked. Definite proof of such connection can be had rapidly by growing cultures from single spores on a medium which favours early and abundant sclerotium development; a modified Dox's agar has been found very suitable for this purpose. Pycnidia and spore formation have not hitherto been detected in pure cultures on any medium. The membranous or subcarbonaceous pycnidia, at first immersed but becoming more or less erumpent at maturity, are globose or depressed globose with an inconspicuous truncate ostiolum and mostly 100–200μ in diameter; a stroma is absent and suggestions of a pseudostroma scanty: the wall consists of 3–4 layers of blackish brown thin-walled angular cells about 9μ in diameter and is lined by a hyaline layer 2–3 cells thick, bearing simple rod-shaped conidiophores 10–15μ in length over its entire surface. The hyaline, continuous, thin-walled conidia with granular contents are variable in shape, elliptical or oval, at times with irregular contour and more or less bent but with no true curvature. The variations in spore size on the same host may be considerable, Shaw giving as a maximum range on jute in India, 16–29 by 6–11μ and Sawada for the same host in Formosa, 16–32 by 7–10μ; the dimensions fall mostly between 16–29 by 6–9μ. The thin-walled conidia, as Shaw has pointed out, have a mean $l : b$ ratio near 3 : 1 and are therefore readily distinguished from the immature hyaline thick-walled pycnospores of *Botryodiplodia Theobromae* Pat. and related forms which show a mean $l : b$ ratio of 2 : 1 or lower.

Petrak has described the *Macrophoma* on sesame stems from the Philippines as the type species of his new genus *Macrophomina* to include pycnidial forms devoid of stroma with long narrow thin-walled elliptical spores which remain hyaline and continuous. With this procedure the author is in agreement as the genus *Macrophoma* is a most heterogeneous group. Petrak and Sydow (16) have in fact been able to refer most of the species

to other genera, *Dothiorella* and *Botryodiplodia* in particular, reducing it to a monotypic genus; the species retained, *Macrophoma pinea* (Desm.) Pet. and Syd. is a more or less stromatic form with large spores 30–50 × 11–20μ and is evidently unrelated to the form considered in this paper. Similar objections apply to its inclusion in *Dothiorella*. As *Macrophoma Phaseoli* Maubl. (1905) is the earliest applicable binomial which the

Measurements in microns of conidia of Macrophomas on jute, sesame, pigeon-pea and beans.

	Observer	μ
Macrophoma Corchori	Shaw	16–27 × 6–8, 17–29 × 6–8, 16–24 × 7–8, 20–27 × 7–9, 16–27 × 7–11, 16–24 × 8–11*
,, ,,	Sawada	16–32 × 7–10
Macrophomina philippinensis	Petrak	16–24 × 6–7·5
,, ,,	Ashby	16–25 × 6–8 (mean of 20 = 20·5 × 7·3)
Macrophoma on sesame fruit Uganda	,,	20–27 × 7–9
Macrophoma on sesame stems Uganda	,,	18–29 × 7–9 (mean of 22 = 25 × 8)
Macrophoma on leaf of jute India	,,	16–28 × 6–8
Macrophoma Cajani	H. and P. Sydow	20–32 × 5–8
,, ,,	Ashby	18–31 × 6–8 (mean of 20 = 26 × 7)
Macrophoma on bean stems S. Carolina and Mississippi	,,	17–30 × 6–9 (mean of 74 = 23·6 × 7·5)
Macrophoma Phaseoli	Maublanc	20–30 × 8–10

* Six sets of measurements on inoculated jute.

author has been able to recognise, the combination *Macrophomina Phaseoli* (Maubl.) nov. comb. is proposed with the undermentioned as synonyms:

Macrophoma Phaseoli Maubl. (1905).
Sclerotium bataticola Taub. (1913).
Macrophoma Corchori Saw. (1916).
Macrophoma Cajani Syd. and Butl. (1916).
Macrophomina philippinensis Petr. (1923).
Rhizoctonia lamellifera Small (1924).
Rhizoctonia bataticola (Taub.) Butl. (1925).
Dothiorella Cajani Syd. and Butl. (1925) (17).
†*Macrophoma Sesami* Saw. (1922).

The sclerotia, which show some differentiation between cortex and medulla, are smooth, black and hard, and variable in size

† A translation of Sawada's description has been obtained; pycnidia 110–160 μ, spores 18–27 × 7–10 μ; on stems and fruits.

and form. In the tissue of herbaceous plants they range from 50–150μ in diameter but in the roots of woody plants Small found them up to ·8 × 1·0 mm. in size in cultures the variation is from 50–200μ.

This sclerotial fungus is of wide geographical distribution, ranging from Formosa, the Philippines, India, Ceylon, East Africa, Palestine and Egypt to the West Indies* and the eastern United States. It causes a seedling blight, stem-rot and root decay of a large range of important economic herbaceous crop plants, a tuber-rot of sweet potatoes and fruit-rot of peppers (18). In Uganda (5), it has been found associated with a root decay of some fifteen introduced woody plants including coffee, cacao and tea, and recently Small (19, 20) has found it in Ceylon in association with root diseases of many woody plants including tea, *Hevea*, cacao and citrus. Its parasitism appears to be much influenced by the effects of environmental and nutritional conditions on the host: its restriction in Uganda to introduced plants is suggestive. In Formosa (22) applications of wood ashes and lime have appreciably reduced losses in jute, and in India (21) on an acid laterite soil, manuring with potash or ash of water hyacinth (*Eichornia crassipes*) has markedly lessened attack on the same host which is sensitive to soil deficiency in available potash.

The author acknowledges valuable help from Mr E. W. Mason, Assistant Mycologist, Imperial Bureau of Mycology, in the preparation of these notes.

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* It was isolated in 1926 from a storage rot of sweet potatoes in Trinidad.

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THE HOST PLANTS OF FOMES ANNOSUS.

By Malcolm Wilson.

The Red Rot or Heart Rot caused by *Fomes annosus* has been long recognised in this and in other countries of Western Europe as one of the most important diseases of conifers. In this country the disease has assumed increasing importance during recent years on account of the extensive schemes of afforestation which are being carried out, and any facts regarding its distribution and biology are consequently of importance.

In this country M. L. Anderson (1, 2) has recently recorded its occurrence on the following coniferous species: *Pinus sylvestris*, *Picea excelsa*, *P. sitchensis*, *Larix europaea*, *L. leptolepis*, *Tsuga albertiana*, *Abies grandis*, *Thuya gigantea* and *Pseudotsuga Douglasii*.

To this list must be added *Pinus Laricio*, *Abies nobilis* and *A. pectinata*, and it appears probable that all coniferous species may be attacked. It has not been observed on *Pinus Strobus* in this country but has been recorded on this species by Hartig (3) and on *Abies balsamea* by Tubeuf (11). Its occurrence on *Juniperus communis* also has been reported by Hartig ((3), p. 186) in Germany, and recently the fungus was found attacking this species in Scotland.

Fomes annosus appears to be chiefly a European species, for although it has been recorded in North America on *Pinus monticola* and other conifers, its occurrence there appears to be unusual and it does not seem to be of any importance as the

cause of disease in the United States (8, 10, 12). Practically all the American conifers that have been introduced into this country have been seriously attacked by the disease, and the fact may perhaps be explained on the supposition that the American fungus differs at least physiologically from the British species.

There is no doubt that *Fomes annosus* does occur on a considerable number of dicotyledonous trees and shrubs but its distribution on these hosts appears to differ considerably in the different countries of Europe. Lind ((5), p. 386) in Denmark records it on eleven dicotyledonous species including *Quercus Robur, Fraxinus excelsior, Fagus sylvatica, Betula alba, Prunus avium, Pyrus Aucuparia, Ulmus montana* and *Calluna vulgaris*. On the other hand, Lagerberg (4) states that he has been unable to find any attack on dicotyledonous trees in Scandinavia. In Germany, however, it has been recorded on *Betula alba* (3), *Corylus Avellana* and *Alnus glutinosa* ((9), p. 61), *Acer* sp. ((7), p. 422) and on *Fagus sylvatica* and *Crataegus Oxyacantha* ((11), p. 450), while Prillieux ((6), T. 1, p. 325) mentions it on five dicotyledonous species including *Quercus Ilex*, although it is not clear that his list refers especially to France. It has been collected on various deciduous trees in North West America (12).

Its distribution on dicotyledons in Scotland appears to be fairly similar to that in France, Germany and Denmark; it has been found on the following species: *Fagus sylvatica, Betula alba, Corylus Avellana, Alnus glutinosa, Prunus Padus, Pyrus Aucuparia, Pyrus Aria, Crataegus Oxyacantha* and *Rhododendron ponticum* var. Up to the present it has not been found on *Calluna vulgaris* in this country and this fact may be of importance, especially in Scotland where heather is found over wide areas which are suitable for afforestation. Its occurrence on *Rhododendron ponticum* which is so commonly found in plantations may be also a fact of considerable significance.

The importance of the occurrence of *Fomes annosus* upon angiosperms rests on the assumption that the fungus from them can infect conifers. No experimental work appears to have been carried out on this point and until it is done the question must be left open.

It is well known that coniferous plantations formed on what was previously arable ground are often severely attacked by *Fomes annosus* and the origin of the fungus in these cases has been somewhat difficult to explain, especially when the plantations are at some distance from other coniferous woods. The fact that the fungus can grow on a number of dicotyledonous trees, among which are several common hedgerow species, seems to offer a possible explanation. Its occurrence on oak and birch

may explain the frequent appearance of the disease when scrub areas, covered by these species, are cleared and planted up with conifers.

I wish to thank Dr A. W. Borthwick and Messrs James Fraser and J. Macdonald of the Forestry Commission and Dr M. L. Anderson and Messrs G. Leven and J. S. L. Waldie who have kindly supplied me with information on this subject.

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THE RATE OF GROWTH OF LICHENS.

By L. Porter, M.Sc., University College, Cork.

Recent work on the rate of growth of lichens has been summarised by Miss Lorrain Smith in the *Transactions* for 1923 and 1925. Linkola's work on species of *Parmelia*, growing on palings, showed the average rate to be 1 mm. per annum. This is exceeded by *P. centrifuga* on rocks, with a rate of 2·5 mm. per annum.

From these measurements the ages of different specimens were deduced, *e.g. P. sulcata*, 30–40 years; *P. centrifuga*, 50–80.

On the other hand, Tobler, in examining species of *Cetraria* on beech and spruce, found that the rate of growth was 1 cm. per annum.

Miss Lorrain Smith points out that Tobler was dealing with young plants, often composite forms from the mingling of

individuals of soredial origin; while Linkola investigated plants that were well established.

The natural conclusion is that rapid growth may occur in young states and favourable circumstances but that it is usually followed by slower growth when a large area has been covered or conditions have become unfavourable.

It would therefore be impossible to deduce the age of any specimen from its measurements since even when the maximum area has been covered a lichen may continue to live by balancing its gonidial and fungal activities, resulting in increase of thickness or development of thalline, soredial or isidial outgrowths. Further, we have as yet few observations on the time required for the development of fructifications.

In lichens on gooseberry bushes the limits of age are easily determined, either from the known age of the bush or the dates of pruning.

Two varieties of gooseberry were recently under observation. One, which naturally and by pruning had chiefly upright branches, was singularly free from lichens. The bark was smooth but powdered with algal forms and occasional soredia. The only lichen on this variety was *Physcia stellaris*. It invariably occupied the angle between two or more branches, *i.e.* the best position for horizontal exposure and the retention of moisture enabling the spores to germinate.

The second variety formed a spreading head of more or less horizontal branches and had a rougher bark. It is constantly being colonized from the adjacent apple and cherry trees. One such bush in its seven years of life, even with two perfunctory prunings, had acquired a large collection of lichens. The following list gives the measurements of its largest specimens:

Ramalina fraxinea Ach.—20 mm. in length.
Parmelia caperata Ach.—50 mm. along a twig.
,, *subaurifera* Nyl.—30 mm. along a twig.
,, *perlata* Ach.—50 mm. × 40 mm. axillary.
,, *sulcata* Tayl.—20 mm. along a twig.
Physcia stellaris Nyl.—28 mm. axillary.
P. stellaris vars. *tenella* and *leptalea*—young, axillary.
Lecidea parasema Ach.—13 mm. round a twig.
Physcia stellaris and *Lecidea parasema* had well developed apothecia.

Other gooseberry bushes provided *Evernia prunastri* Ach. and *Usnea hirta* Ach. *U. florida* Web. does not occur in the neighbourhood.

Graphis and allied species were absent, although plentiful on neighbouring sweet briar and hawthorn. This might be due to their preference for a smoother bark, coupled with the fact that the algal forms on the smooth-barked gooseberries did not include *Trentepohlia*.

Red currant bushes of about the same age are mingled with the gooseberries. They provided *Physcia stellaris, Parmelia caperata, P. subaurifera, Ramalina fraxinea, Lecidea parasema, Biatorina premnea* and *Xanthoria parietina.*

Black currant of less luxuriant growth had only *Physcia stellaris* and *Lecanora subfusca.* The young forms of *Physcia* were of interest as they showed that *Ph. tenella* is distinguishable in its earliest infancy from *Ph. stellaris.* In several instances two thalli crowded together were not only distinguishable but easily separable, which is not so with *Ph. tenella* and *Ph. leptalea,* since the hooded and the flattened tips appear together on the same plants at early and late stages. Large specimens of the same plant from palings near the sea, west of Kinsale, Co. Cork, show such strong divergence from the *stellaris* type as to favour separation as the *Physcia hispida* Tuckerm.

The most striking development of lichens is attained by plants which have grown in the angles made by two or three branches, a favourite position for *Parmelia perlata* and *Physcia stellaris. Parmelia sulcata* can exist similarly, but *P. caperata* must be closely pressed to the surface, and when it has encircled a twig it extends longitudinally. The specimens of *P. perlata,* measured above, had reached the largest size consistent with its position. The three unattached edges had continued their activity by a large development of the characteristic undulations with sorediate surfaces.

The preference of lichens for horizontal exposure is due to the dimmer light of this moist climate and to the longer retention of moisture on the horizontal plane.

Miss Lorrain Smith describes the work of Plitt on the lichens of Jamaica. He concluded that light was the most important factor in their existence. When he further studied the lichens of Maine, endeavouring to correlate the evaporating power of the air, the intensity of light and the distribution of lichens up and around a tree, he decided that evaporation was the determining factor. This apparent contradiction may be due to differences in climate between Jamaica and Maine. As a rule, the greater the illumination the greater is the evaporation. But in a moist climate such as that of the south-west of Ireland, lichens certainly flourish best where exposed to the greatest illumination, which for gooseberry bushes is on the horizontal branches. In trees, such as apple and cherry, the uppermost and outermost branches are most richly covered with lichens, and for larger trees, such as beech, an exposed trunk is the favourite habitat, but if the trunk is short or shaded by branches leprous forms are abundant, but there is no great development of lichens until the trunk has reached considerable size. Several

very high beech trees, more than 150 years old and which were unbranched for 30 feet or more were examined. The branches had developed on the southern and western sides in spite of the prevalent south-westerly gales, consequently the northern side had the greatest illumination and was covered with lichens, especially *P. caperata*. The largest specimen of this species which had probably developed from a single centre during the last 100 years had an area of about 80 sq. cm., indicating a rate of growth comparable with an advance of 1 cm. per annum.

ON SPECIES OF THE GENUS NIGROSPORA ZIMMERMANN RECORDED ON MONOCOTYLEDONS.

(With Plate XV.)

By E. W. Mason, M.A., M.Sc., Imperial Bureau of Mycology.

Introduction.

In 1921 a number of specimens from Uganda were received at the Imperial Bureau of Mycology for determination; among these was a black-spored Hyphomycete on rice, which was recognised to be the fungus known at Pusa, India, as *Epicoccum hyalopes* Miyake (Fig. 6). In 1924 Petch redescribed *Monotospora Oryzae* B. and Br. on the same host, and referred it to Zimmermann's genus *Nigrospora* as *N. Oryzae* (B. and Br.); specimens of this were received shortly afterwards from the Gold Coast, W. Africa, and on revision it became clear that *Nigrospora Oryzae* and *Epicoccum hyalopes* were very closely related if not identical fungi. A very similar organism was shortly afterwards observed on maize leaves from the Gold Coast for which a host index suggested the name of *Coniosporium Gečevi* Bubák (Fig. 5). An isolation from banana fruits (Fig. 3) received from the West Indies, again gave a similar fungus which in culture suggested Molliard's species *Basisporium gallarum* (Fig. 1), and was also reminiscent of Cavara's picture of his *Acremoniella occulta* (Fig. 7).

The systematic position of these closely related organisms became no clearer when Miss Dale's culture of *Basisporium gallarum* Moll. from the Centraalbureau voor Schimmelcultures was examined. It was found not to be a similar organism at all.

It is inconvenient to be compelled to look for closely related species in such diverse genera and an attempt is here made to bring together a number of these congeneric species recorded on Monocotyledons. So far as may be possible at a first attempt,

I have sorted them out into their apparent morphological species.

Basisporium gallarum Moll.

Molliard in May 1902 described and figured *Basisporium gallarum* (No. 20)* gen. nov., spec. nov., on a fungus growing on dead larvae of *Lipara lucens* found in some galls on *Phragmites communis* in France; the fungus was described from cultures. The essentials are as follows:

It grew rapidly on nutrient media, especially nitrogenous ones; the hyphae are at first hyaline, but the sterile ones quickly turn brown and attain a maximum diameter of 18μ; the fertile hyphae only slowly turn brown, are of a diameter of 4μ, and bear terminally and laterally "basidia ampullifera," *i.e.* squat inflated vesicles, on which the spores are borne singly. The spores (Fig. 1) become black and quite opaque. They are round when seen from the apex but in side view are rather pointed at the top and flattened at the base. They show very little variation in size and measure 14μ in long diameter, *i.e.* across the poles, and 11μ in short diameter, *i.e.* in the axis of the poles.

In 1912 Miss Dale, who was isolating soil fungi at Woburn, England, recorded doubtfully, *Basisporium gallarum*; she deposited her culture at the Centraalbureau voor Schimmelcultures, where it is still maintained, and from which, as mentioned above, a subculture was obtained and examined. The hyphae are hyaline, rather narrow and diffluent; the spores are a lightish brown and remain transparent; they are borne directly on the hyphae or on short pedicels. They are generally round from every view point (*i.e.* globose) (Fig. 2 *a*); they are sometimes elongated in the direction of the main axis and very occasionally become uniseptate (Fig. 2 *b*).

This agrees fairly well with Miss Dale's description, although she says that the spores are deep brown or black. An original slide of this culture is preserved at the British Museum and I have examined it through the courtesy of Mr Ramsbottom. It shows that the present culture has not changed materially since 1912. It does not, however, belong to Molliard's genus as here understood.

I have seen no other published records of *Basisporium gallarum* for Europe. In July, 1926, however, Dr Peyronel, of the Stationе di Patologia Vegetale, Rome, kindly forwarded me specimens which he had determined as *B. gallarum* (No. 20 B) in wheat culms from Piedmont, Italy. The specimens were growing among insect eggs and detritus. I have no doubt at all that the specimens were correctly determined.

* For numbers after specific names, see table on pp. 154–155, col. 2.

LIST OF RECORDS OF *NIGROSPORA* SPP. ON MONOCOTYLEDONS, WITH THE MEASUREMENTS OF THE LONG AXIS OF THE SPORE IN μ.

(Names in italics are not certainly referable to *Nigrospora*.)

Host	No.	Fungus, name and authority	Date	Origin of material examined	Diagnosis	No. of spores measured	10μ	11μ	12μ	13μ	14μ	15μ	16μ	17μ	18μ	19μ	20μ	21μ	22μ	23μ	24μ
Maize	1	*Sporotrichum Maydis* Garov.	1873	No type material in existence	14 to 15·5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	1 B	Trichosporium Maydis Sacc.	unpubl.	Ex Mycotheca Saccardiana, Trotter 1911	.	50	.	.	1	17	25	4	3	.	.	.	.	.	.	.	.
	2	Trichosporium sphaericum Sacc.	1882	Ellis, North American Fungi, No. 968 in Herb. Kew	16 to 18	50	.	.	.	.	.	3	9	15	22	1	.	.	.	.	.
	4	*Monotospora nigra* Morgan	1895	None examined	14 to 18	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	5	*Mycogone nigra* (Morgan) Jensen	1912	ditto	12 to 15	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	6	Coniosporium Gečevi Bubák	1912	ditto	15 to 20	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	7	Coniosporium Gečevi Sacc.	1912	ditto	13 to 15	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	8	Basisporium gallarum Durrell	1925	ditto	13 to 18	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	9	—	unpubl.	C.B. 231 on maize leaves from Gold Coast	.	25	.	.	.	.	.	1	7	5	10	.	2	.	.	.	.
	10	—	unpubl.	Slide of cultures isolated from same	.	50	.	.	.	.	2	3	7	9	14	7	6	1	1	.	
	11 B	Nigrospora javanica Palm	1918	—	22 to 30	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Rice	1 A	*Sporotrichum Maydis* Garov.	1874	—	14 to 15·5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	12	Monotospora Oryzae B. and Br.	1873	Type material in Herb. Kew	12·5 to 15	100	.	1	10	34	36	13	6	.	.	.	.	.	.	.	.
	12 A	Nigrospora Oryzae (B. and Br.) Petch	1924	Co-type material at Peradeniya	9 to 16	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	12 B	Nigrospora Oryzae I. B. M.	1924	Gold Coast, C.B. 103. Slide of portion of a rice leaf	.	50	1	0	0	10	25	13	0	0	1	.	.	.	.	.	.
	12 C	—	unpubl.	Philippine material found in Baker, Fungi Malayana 218 in Herb. Kew	.	25	.	1	1	3	14	6	.	.	.	.	.	.	.	.	.

	13	Epicoccum hyalopes Miy.	1910	None examined	14 to 18 (by 13 to 15)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	13 A	Epicoccum hyalopes I. B. M.	unpubl.	Uganda from J. D. Snowden, No. 678	.	50	.	.	.	.	.	2	9	12	17	9	1	.	.	.	.
Sugar-cane	14	Epicoccum levisporum Pat.	1893	Type material examined	15	50	.	.	.	.	1	4	12	9	22	2	.	.	.	.	.
	15	Coniosporium extremorum Syd.	1913	ditto	13 to 20 (or 15 to 20 × 12 to 17)	50	.	.	.	1	3	2	17	18	8	1	.	.	.	.	.
	16	Glenospora Sacchari Speg.	1896	ditto	20 to 22 × 15 to 18	50	.	.	.	.	.	.	1	0	4	9	13	11	6	3	3
	17 C	—	unpubl.	Also present on type material of last species	.	50	.	.	2	7	29	11	1	.	.	.	.	.	.	.	.
	17 D	—	unpubl.	Culture isolated by E. F. Shepherd, Mauritius	.	75	.	2	5	16	34	14	5	.	.	.	.	.	.	.	.
	17 B	Acremoniella occulta Ashby	unpubl.	On leaf spot, Barbados from S. F. Ashby	.	37	.	2	7	10	11	6	1	.	.	.	.	.	.	.	.
Coco-nut	18	Memnonium palmicolum Cke.	1877	Type material in Herb. Kew	15	50	.	.	.	2	14	21	13	.	.	.	.	.	.	.	.
Coco-nut and banana	17 A	Acremoniella occulta Ashby	1913	None examined	13 to 15·5 × 10 to 13	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	22	—	unpubl.	Isolated from banana fruits and also leaf bases, W. Indies	.	50	.	.	.	.	1	2	13	14	20	.	.	.	.	.	.
Arundo conspicua	19	Hadrotrichum arundinaceum Cke. and Mass.	1887	Type material in Herb. Kew	30μ	50	.	.	.	.	1	0	7	10	17	10	5	.	.	.	.
Arundo Phragmites	20	Basisporium gallarum Moll.	1902	None examined	14 × 11	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Panicum amphibium	21 A	Nigrospora Panici Zimmerm.	1907	ditto	25 to 30 × 22 to 25	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	21 B	Nigrospora Panici Kuyper	unpubl. (?)	Culture from Centraalbureau (host not stated)	.	50	.	.	1	2	7	4	9	6	16	3	2	.	.	.	.
Wheat	11 A	Nigrospora javanica Palm	1918	—	22 to 30	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	17	Acremoniella occulta Cavara	1893	—	13 to 15 × 9 to 12	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	20 B	Basisporium gallarum Peyronel*	unpubl.	Received from Italy July 1926	.	50	.	.	3	20	24	3	.	.	.	.	.	.	.	.	.
Gynerium	23	Coniosporium micans Gaja	1912	None examined	18 to 20	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

* This specimen has since been accepted by Prof. Cavara as his *Acremoniella occulta*.

The genus *Nigrospora*.

Some months before Molliard's paper was published, Zimmermann in Java (February, 1902) had established the genus *Nigrospora* on *N. Panici*, spec. nov., growing on the leaves of *Panicum amphibium* (No. 21 A and Fig. 8). He describes and figures a typical *Basisporium* apparatus protruding through a stoma; the black opaque spores are borne singly on a short dark grey conidiophore (*i.e.* the vesicle) and both are surrounded by a hyaline layer, which is no doubt the mucus covering which sometimes in culture may be seen dripping from the spore. The spores measured 25 to 30μ × 22 to 25μ, being larger than any I have verr met. There would appear to be no question but that Zimmermann was dealing with an organism strictly congeneric with Molliard's *Basisporium gallarum*. He was not successful in getting his species into culture. Recently a culture received from the Centraalbureau voor Schimmelcultures labelled *Nigrospora Panici* (No. 21 B), and isolated by Kuyper, proves to be a typical *Basisporium*; whether it represents Zimmermann's species is not quite certain; its host is not stated and the spore measurements are considerably less. *Nigrospora* is accepted in the present paper as the correct generic name to which these species should be referred.

The results of examining a number of collections of these species are given in the table on pp. 154–155. The long diameter of a number of spores was measured in each case to the nearest micron; the short diameter of an opaque spore cannot be so readily measured and appears to be an unsuitable character for tabular presentment. In material of any age, the spores seen from the side appear to be quite elliptical in optical section; and in the larger spored strains I have not observed that the apex is ever distinctly pointed.

Nigrospora on Banana and Coco-nut.

Two isolations from West Indian banana plants, one from the fruit and one from the petioles, made at the Imperial Bureau of Mycology, gave the same species of *Nigrospora* (No. 22, Fig. 3). The great mass of conidia showed in their long diameter a range of 16 to 18μ.

In 1913, Ashby determined a fungus on banana and coco-nut leaves in Jamaica as *Acremoniella occulta* Cavara (No. 17 A and Fig. 4); his figure shows that he was dealing with a *Nigrospora*, and a later determination by him of *Acremoniella* on sugar-cane (No. 17 B) from Barbados which he has kindly allowed me to examine, confirms this view. The spore measurements given were 13 to 15·5μ × 10 to 13μ.

Later, a culture was received of *Nigrospora* (No. 17 D),

isolated by E. F. Shepherd of Mauritius from sugar-cane. The mass of its spores showed a long diameter of 13 to 15μ, thus agreeing with Ashby's figures for his banana and coco-nut fungus and, incidentally, well enough with Molliard's description of *Basisporium gallarum*. In the two cultures under observation, the two mean spore sizes have shown no tendency to run into one another, which seems to show that there are two distinct strains, if not indeed species, of *Nigrospora*, and that both occur on the banana plant. As will appear, the same two strains seem to be indicated also on maize, rice and sugar-cane. For reasons which will be given later, the larger spored strain is referred to *N. sphaerica* and the smaller spored strain to *N. Oryzae*.

In 1887, Cooke shortly described *Memnonium palmicolum* (No. 18) on coco-nut leaves from Demerara, British Guiana. The type specimen shows that it is a *Nigrospora*. It belongs to the *N. Oryzae* group, but has a considerable number of spores with a diameter of 16μ. Saccardo (1886) lists the fungus as *Trichosporium palmicolum* (Cke) Sacc.*

Nigrospora on Maize.

About 1870 an idea was current in Italy that "pellagra" was due to excessive eating of foods prepared from maize, especially when the latter had been subjected to fungus attack. A doctor forwarded a sample to Pavia for examination and in 1874 Garovaglio, the Director, published a report. The grain had been damaged in the field by hail, and was cracked and variously distorted. A black spored fungus (diam. 14 to 15·5μ) was found growing on the grain at the points of damage, especially where the endosperm was cracked. It was named *Sporotrichum Maydis* (No. 1), in Rendic. R. Ist. Lomb. ser. 2. vi (1873), p. 242.

Saccardo (1886) listed the fungus as *Trichosporium Maydis* (Garov.) Sacc., and Ferraris (1910) as *T. Maydis* (Cattan.) Sacc. Both refer to the same fungus. From the original description and figure of the fungus, I do not think that it can be referred with any certainty to *Nigrospora*. Professor Montemartini informs me that no type material is available at Pavia. So far as I can find out, the first specimen referred to this species and now in existence, was collected in Avellino, Italy, by Professor Trotter in July, 1911 (No. 1 B); I am informed that it was studied by Saccardo in whose herbarium it now remains. Through the courtesy of Professor Gola, a small sample, consisting of two maize grains, has been examined. The outer skin of the grains is broken and the fungus is growing through the

* *Trichosporium* Fr. was emended by Saccardo and is now a very composite genus. No Friesian species are known. According to von Höhnel (1923), *Memnonium* Corda is really the correct generic name for *Stachybotrys* Auct. non. Corda.

endosperm. It is a *Nigrospora* of the small spored type, and appears to me exactly similar to *Nigrospora Oryzae* (B. and Br.) Petch, authentic material of which dates back to 1873.

Trichosporium Maydis was also recorded by Montemartini (1925) on maize grains in Padua; but I have had no opportunity of examining it. Unless authentic material of this species can be found it would appear to be well to let the name lapse.

Meanwhile, Ellis had sent a large batch of fungi from New Jersey, U.S.A. to Saccardo who (1882) shortly described a black spored fungus (16 to 18μ diam.) on maize culms as *Trichosporium sphaericum* (No. 2). Ellis issued an exsiccatum in his North American Fungi, No. 968. The specimen in Herb. Kew corresponding to the diagnosis is a species of *Nigrospora* and gives a basis for the earliest known specific name of the larger spored group. As Table I shows, the Gold Coast specimens C.B. 231 (Nos. 9 and 10) on maize leaves agree with the spore measurements of this species, which is accordingly called here *N. sphaerica* (Sacc.) comb. nov.

In 1895 Morgan founded *Monotospora nigra* (No. 4) on a black spored form on maize stalks in Ohio, U.S.A.; but the publication has not been seen nor are specimens available. Morgan's description as given by Saccardo (*Syll.* XIV, p. 1075) suggests *Nigrospora*. In 1912 Jensen, at Cornell, repeatedly isolated from the soil of maize fields a fungus which he identified as Morgan's species. He considered that the fungus had two-celled spores, the upper cell dark brown, smooth, thick-walled globose; the lower cell hyaline to slightly coloured, smooth, hemispherical. He referred it to *Mycogone*, as *M. nigra* (Morgan) Jensen (No. 5). I regret that I have not been able to learn anything about this species.

In 1909, Heald and Pool in Nebraska, U.S.A., were examining "moldy corn," and from it isolated *Melanospora pampeana* Speg. In culture this was found to form perithecia freely if grown with, or following, certain maize cob fungi of which *Basisporium gallarum* was the most satisfactory*.

In 1912, Bubák examined some maize cobs received from Bulgaria and found the axis infested with a black spored fungus which he named *Coniosporium Gečevi* (No. 6 and Fig. 5); he did not have the opportunity of determining whether or not it was parasitic.

Meanwhile, in 1911, there had been trouble with stored maize grain in Ohio, U.S.A., the state where Morgan had worked. The investigation was entrusted to Arzberger, who reported in 1913. He found a black spored fungus permeating the tissue of

* What is apparently the same *Melanospora* appeared on banana plants at the Imperial Bureau of Mycology in 1924 and 1925 among a number of other fungi. It formed abundant perithecia in culture following a species of *Fusarium*.

the cob and isolated it repeatedly. He determined that it was a *Coniosporium*, and sent specimens to a number of systematists, including Saccardo, and Bubák. Bubák stated that it was the same as his *Coniosporium Gečevi* and forwarded some of his own material in support of this assertion. Saccardo (1912) at first stated that it was a new species of *Coniosporium*, but later confirmed Bubák's opinion. His own point of view, I think, emerges from his note (*loc. cit.*). In Bubák's diagnosis, the spore diameter is given as 15 to 20μ. Saccardo states that *C. Gečevi* (No. 7) differs from *Coniosporium micans* Gaja on *Gynerium* in the spore diameter being 13 to 15μ, as opposed to 18 to 20μ, and in occurring on the caryopses and not on the culms. Arzberger's general conclusion was that the fungus grew as a saprophyte in the tissues of the cob after maturity, usually appearing while the corn was in stook.

In 1918 Palm noted that the Javanese fungus *Nigrospora javanica* Zimmerm. (No. 11 B) occurs on maize and rice as well as on wheat. It may be noted that Palm intended to cite *N. Panici* Zimmerm. which is the only combination in this genus which Zimmermann made. A culture received from the Centraalbureau labelled *N. javanica* proved to be a very poorly sporing strain of *Nigrospora* and, as mentioned above, a second strain, labelled *Nigrospora Panici* (No. 21 B), was a freely sporing and typical *Nigrospora* as here understood.

In 1922 Ramsey described and figured *Basisporium gallarum* as causing a rot of tomatoes and stated that *Basisporium* had been isolated from several sources including maize. Following this paper, the *Coniosporium Gečevi* of Ohio was determined as *Basisporium gallarum* (No. 8) and in 1925 Durrell published a progress report on the damage which the fungus does in the State of Iowa. The shank of the maize is attacked and so retted that the ear may fall off at harvest. In the tissue of the ears the fungus grows luxuriantly and the kernels become loose and the fungus may be found fruiting in the kernels. Sometimes the embryo itself is invaded. There is a very marked relationship between humidity and the occurrence of *Basisporium* disease. From Durrell's account it is quite certain that he was dealing with a *Nigrospora*.

As already stated, material of both the large spored group of *Nigrospora* (Nos. 2, 9 and 10) and of the small spored group (No. 1 B) has been examined. Consideration of the other records affords evidence that the two groups have already been differentiated on maize. *Coniosporium Gečevi* (No. 6) was described by Bubák as being 15 to 20μ in diameter; by Saccardo (No. 7) from material from Bubák and the U.S.A. as 13 to 15μ. There is the hypothetical case of *Monotospora nigra* Morgan (No. 4) (14 to

18μ) and *Mycogone nigra* (Morgan) Jensen (No. 5) (13 to 15μ), and the *Sporotrichum Maydis* of Garovaglio and Cattaneo, which, if it was a *Nigrospora* at all, belonged to the small spored group.

Nigrospora on Rice.

In 1874 (No. 2) Garovaglio recorded his *Sporotrichum Maydis* (No. 1 A) on rice glumes in Italy, and this was confirmed by Cattaneo in 1877. The fungus does not appear to have been recognised on rice since that date, though von Thümen (1889) and Miyake (1910) carry it forward in their list of rice fungi.

In 1873 however Berkeley and Broome shortly described *Monotospora Oryzae** (No. 12) on rice leaves from Ceylon with a spore diameter of 12·5 to 15μ. It does not appear to have been recognised again until Petch drew attention to it in 1924. He considered it was not a good *Monotospora* and refers it to Zimmermann's genus *Nigrospora* as *N. Oryzae* (B. and Br.) Petch (No. 12 A). He had found it recently in quantity on rice suffering from "Senthal" (red-stalk), but it was not considered the cause of the disease. The type specimen in Herb. Kew shows it to be a good *Nigrospora* as here understood, and as it is the first species of which authentic material is in existence, I think that it must be called *N. Oryzae* (B. and Br.) Petch. As Table I shows, it belongs to the smaller spored group, to which it gives its name. The Gold Coast specimen C.B. 103 (No. 12 B) is the same, and I have also found it on Philippine material of rice (No. 12 C), included in Baker, *Fungi Malayana*, No. 218, labelled *Coniosporium oryzinum* Sacc.†

In 1910 Miyake described and figured *Epicoccum hyalopes*‡ (No. 13, Fig. 6) on rice glumes in Japan. The spore measurements are given as 14 to 18μ × 13 to 15μ. I have not seen any authentic material, but it seems undoubtedly to be a *Nigrospora*. Material from Burma has been recognised as this species at Pusa (Butler, 1913) and it is also recorded for Uganda. The Uganda specimens from Snowden (No. 13 A) are *Nigrospora* and referable to *N. sphaerica*.

* The type species of *Monotospora*, *M. toruloides* Corda, is now unknown. Berkeley and Broome conceived the genus as characterised by differentiated conidiophores (of the *Helminthosporium* type) bearing single black spores. Their earliest species are not known in culture.

† Saccardo's species (1916) is a *Coniosporium* of the *C. Arundinis* type. This type forms a well-marked group in the genus *Coniosporium*; it is referred by Grove to *Melanconium*; by von Höhnel to Fries' old genus *Papularia*, and in culture is apparently the same as Tengwall's genus *Pseudobasidium*. It is very inconvenient to have this group of *Coniosporium* mixed up indiscriminately with *Nigrospora* spp. in the genus *Coniosporium*. The majority of species referred to *Coniosporium* which are recorded on Monocotyledons belong to this group.

‡ The better known species of *Epicoccum*, *e.g. E. neglectum* on maize are quite diverse from *Nigrospora*.

So of the four collections of *Nigrospora* on rice examined by the author, three fall into the *N. Oryzae* group and one into the *N. sphaerica* group.

Nigrospora on Sugar-cane.

In 1893 Patouillard described *Epicoccum levisporum* (No. 14) on the leaves of sugar-cane at San Nicolas, S. America, and by his courtesy the type specimen has been examined, and is undoubtedly *Nigrospora*. In 1913, Sydow described *Coniosporium extremorum* (No. 15) on leaves of sugar-cane from the Philippines. A portion of the type specimen was kindly given me by Professor Samuelson of the Riksmuseets, Stockholm. It is a *Nigrospora*. These two collections are identical and fall within the *N. sphaerica* group.

In 1896 Spegazzini described *Glenospora Sacchari** (No. 16) on sugar-cane at Tucumán, La Plata. He very kindly lent me this collection with its original envelope, on which he has figured a typical *Nigrospora*. He gives the spore measurements as 20 to 22μ × 15 to 18μ, and my measurements on three preparations confirm these figures, which indicate a larger form than we have yet met with. A fourth preparation, however (No. 17 c), gave me the *N. Oryzae* form, which matches Shepherd's culture (No. 17 d) from sugar-cane. It is also matched by a fungus on some pickled material of *Phyllosticta* leaf spot of sugar-cane from Barbados which was given me by Mr Ashby as a sample of his *Acremoniella occulta* (No. 17 b)†.

In 1917 Johnston and Stevenson recorded *Basisporium gallarum* on sugar-cane in Porto Rico, but no spore measurements are given. They write: "This is one of the very common saprophytic forms encountered in the work with cane fungi, it being found on all parts of dead and dying plants after forming black, irregular patches, especially on leaves and dead seed pieces. It has turned up in culture several times, in one instance of a top rot case and of various leaf spots, but inoculations with it have not been successful. It also occurs on other grasses *Panicum barbinode, Eriochloa subglabra.*"

Of the seven specimens of *Nigrospora* examined by the author on sugar-cane, four are referable to *N. Oryzae*, two to *N. sphaerica* and one, *Glenospora Sacchari*, is a very large spored form which, although it is not known whether it will be distinguishable in culture, it appears best to distinguish for the time as *N. Sacchari* (Speg.) comb. nov.

* The type species of the genus *Glenospora* is *G. Curtisii* Berk. and Desm. This species is not properly understood, but it is not a *Nigrospora*.

† A collection on sugar-cane from Uganda, just received, is also referable to *N. Oryzae*.

Nigrospora on other hosts.

In 1893 Cavara, working at Pavia, described and figured *Acremoniella occulta** (No. 17, Fig. 7) on culms from a cornfield near Florence, Italy. Later writers agree in stating that the host plant was wheat. The spore measurements are given as 13 to 15μ × 9 to 12μ. As his figure shows, the spores resemble *Nigrospora* spores and the measurements agree with those of *N. Oryzae*. It is hard to believe that Ashby's determination (No. 17 A) of this fungus is not correct. There is, however, no authentic material of this fungus at Pavia, and it is perhaps better not to cite the fungus as certainly *Nigrospora*†. Stevenson (1926) states that the fungus occurs on wheat and rye in Great Britain and Italy, but I have not traced his authorities for this statement. The only other record of a *Nigrospora* on wheat that I have is Palm's record of *Nigrospora javanica* causing a glume spot of wheat.

In 1887 Cooke and Massee described *Hadrotrichum arundinaceum*‡ on *Arundo conspicua* at Kew, England (No. 19), and in 1893 Massee published a small figure, which does not bring out the essential characters. The diagnosis gives the spores as sub-globose and 30μ in diameter; but although the type specimen in Herb. Kew shows that the fungus is a *Nigrospora*, I have found no spores approaching 30μ in diameter; on the contrary, morphologically this fungus falls into *N. sphaerica*.

Coniosporium micans Gaja (1912), on *Gynerium* in a cool house in Italy, is only mentioned here because of Saccardo's statement (1912) that it is similar to *C. Gečevi*§.

* The type species of *Acremoniella* is *A. atra* Sacc. *Nigrospora* has little in common with this species.

† Dr Peyronel points out that his specimen of *Basisporium gallarum* on wheat culms from Piedmont, Italy, agrees exactly with the measurements given by Cavara for *A. occulta* (see p. 153).

Since the above was written it has been found possible to submit to Professor Cavara the specimen No. 20 B on wheat culms from Italy, which was received from Dr Peyronel determined as *Basisporium gallarum* Moll. and queried as *Acremoniella occulta* Cavara. Professor Cavara agrees that this specimen represents his species, which accordingly falls into *Nigrospora Oryzae* (B. and Br.) Petch; it should be stated, however, that Professor Cavara was not satisfied that his species and *Basisporium gallarum* Moll. were the same thing.

‡ At this date, the type species of *Hadrotrichum*, *H. Phragmitis*, was confused with *Napicladium arundinaceum*. The most commonly copied picture of the former is considered to represent really the conidiophores of the latter turned upside down.

§ I have no evidence that *Coniosporium micans* is a *Nigrospora* although the diagnosis strongly suggests it. On the need for caution, compare Saccardo's footnote on *Trichosporium insigne* Mass. and Salm. (*Syll.* XVIII, p. 574), "A *T. sphaerica* Sacc. hyphis hyalinis et conidiis verruculosis differt." The chief resemblance is that the respective authors of these two species have each referred his species to the genus *Trichosporium*.

Glenospora elasticae Koorders (1907) (Fig. 9) on *Ficus elastica* from Java is, from its figure and description, clearly a *Nigrospora*. Its spore measurements are said to be 14 to 16μ × 12 to 12·5μ. It is mentioned here as it is the only *Nigrospora* that I have found with a figure published under the name of *Glenospora*. There is no authentic material at Berlin, and unless a slide is preserved at Java, probably none is in existence.

CHRONOLOGICAL LIST OF SPECIES OF *NIGROSPORA*.

(Species in italics not known to me and doubtful species of *Nigrospora*.)

	Name	Suggested name
1873	*Sporotrichum Maydis* Garov.	? N. Oryzae
	[*Trichosporium Maydis* (Garov.) Sacc.]	
1873	Monotospora Oryzae B. and Br.	N. Oryzae
	[Nigrospora Oryzae (B. and Br.) Petch]	
1877	Memnonium palmicolum Cke.	N. Oryzae
	[Trichosporium palmicolum (Cke.) Sacc.]	
1882	Trichosporium sphaericum Sacc.	N. sphaerica
1887	Hadrotrichum arundinaceum Cke. and Mass.	N. sphaerica
1893	Epicoccum levisporum Pat.	N. sphaerica
1893	Acremoniella occulta Cav.	N. Oryzae
1895	*Monotospora nigra* Morgan	(?) N. sphaerica
	[*Mycogone nigra* (Morgan) Jensen]	(?) N. Oryzae
1896	Glenospora Sacchari Speg.	N. Sacchari
1902	Nigrospora Panici Zimmerm.	Nigrospora sp.
1902	Basisporium gallarum Moll.	N. Oryzae
1907	Glenospora elasticae Koorders	N. Oryzae
1910	Epicoccum hyalopes Miyake	N. sphaerica
1912	Coniosporium Gečevi Bubák	N. sphaerica
1912	*Coniosporium micans* Gaja	(?) Nigrospora sp.
1913	Coniosporium extremorum Syd.	N. sphaerica
1918	Nigrospora javanica Palm	Nigrospora sp.

Summary.

A number of records of black spored Hyphomycetes occurring on Monocotyledonous hosts are referable to the genus *Nigrospora* Zimmermann (Synon. *Basisporium* Molliard). Spore measurements indicate that three species may be provisionally accepted. There is, at the moment, no evidence that the different strains can be classified by the host on which they occur or by their country of origin.

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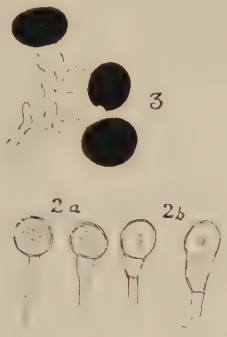

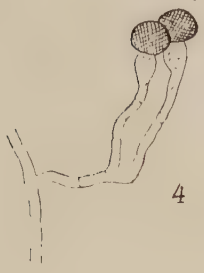

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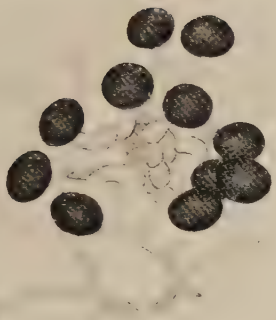

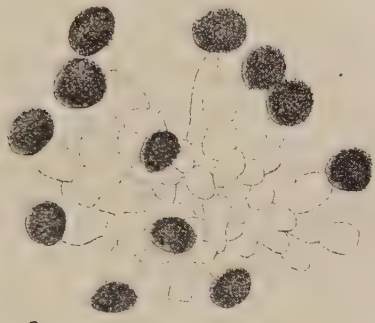

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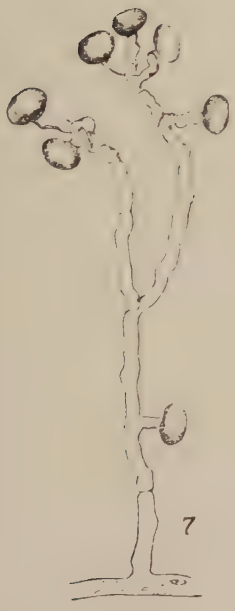

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EXPLANATION OF PLATE XV.

Fig. 1. *Basisporium gallarum* Moll. After Molliard.
Fig. 2. *Basisporium gallarum* Dale nec Moll. Orig.
Fig. 3. *Nigrospora* sp. isolated from banana. Orig.
Fig. 4. *Acremoniella occulta* Ashby (1913). After Ashby
Fig. 5. *Coniosporium Gečevi* Bubák. After Bubák.
Fig. 6. *Epicoccum hyalopes* Miyake. After Miyake.
Fig. 7. *Acremoniella occulta* Cavara. After Cavara.
Fig. 8. *Nigrospora Panici* Zimmer. After Zimmermann.
Fig. 9. *Glenospora elasticae* Koorders. After Koorders.

All magnifications approx. × 375; all reproductions have been calculated from the author's diagnosis; this has led to altering three published magnifications.

Species	Published magnifications	Corrected to agree with diagnosis
Basisporium gallarum	approx. × 1000	approx. × 720
Nigrospora Panici	× 450	at least × 660
Epicoccum hyalopes	× 600	approx. × 270

ALEURIA REPANDA PERS.

(With 4 Text-figs.)

By Jessie S. Bayliss Elliott, D.Sc. (Birm.), B.Sc. (Lond.).

(1) Response of the Apothecia to Light.

In June 1926 some hundreds of fruit-bodies of *Aleuria repanda* Pers. came up in my garden tool-shed. The light arrangements in the shed and the uneven surface of the substratum on which the fungi were growing afforded an excellent opportunity for

Fig. 1. Photograph showing the reaction of the apothecia to light. The light entered the dark shed from the right-hand side. The discs are at right angles to the incident light, while the stalks are parallel with it.

observing that the fruit-bodies are sensitive to light and capable of carrying out heliotropic curvatures. During the time the apothecia were forming, the window of the shed had been covered with planks, and thus the shed had been converted into a large dark chamber which received light only through the door, where it entered through a small hole and a chink at the base. The fungus grew on an old jute hearth rug, used occasionally for protecting a garden frame; while wet it had been folded into a rectangular form and placed in a corner of the shed opposite the door; instead of lying flat, a portion was reared vertically in a plane parallel with the door at right angles to the

incident light and the rest formed a shallow trough, whose vertical sides were at right angles to the door and parallel with the incident light.

When quite young the apothecia resembled tiny goblets with a short stalk; when about one-third grown the short stalks were still visible but the cup-like portion became flattened and revolute at the margin. The diameter of the discs at this stage was about 3 cm. It was evident that the apothecia were

Fig. 2. Heliotropic curvatures of asci and paraphyses. × 550.

adjusted to the direction of the incident light because all the discs were arranged in vertical planes parallel with the door, that is, at right angles to the incident light (Fig. 1).

To bring about this adjustment, all the stalks of the apothecia growing on the back vertical portion of the rug stood out from it at right angles, while the stalks of those growing on the vertical sides of the trough-like portion curved round at the base and assumed a horizontal position in planes parallel with the vertical sides (Fig. 1). By this heliotropic response of the

very short stalk, the hymenial surfaces of the apothecia were placed at right angles to the incident light. Apart from this response, which might be considered a kind of coarse adjustment of the fruit-body, the asci and paraphyses also responded to the stimulus of light (Fig. 2 *a*, *b*, *c* and Fig. 3). Asci are first

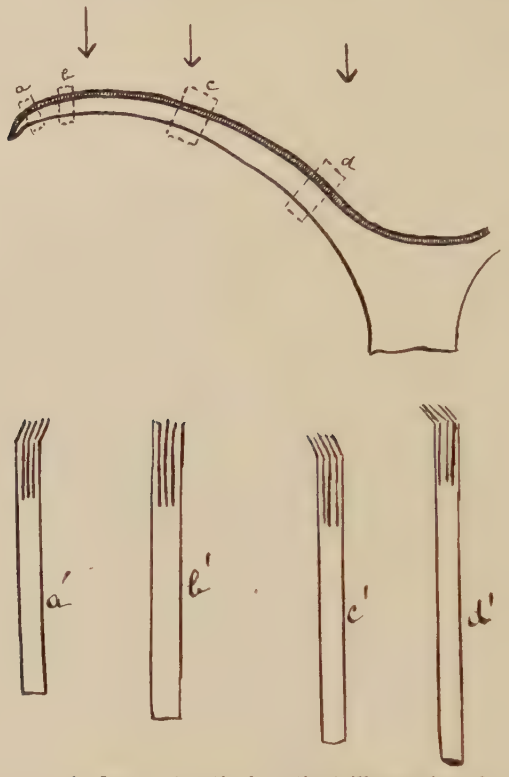

Fig. 3. Diagrammatic figures (vertical section) illustrating the curvatures of asci in a moderately young apothecium when subjected to unilateral illumination. Arrows show the direction of the light. Portions are taken from positions (*a*, *b*, *c*, *d*) and much enlarged at (*a'*, *b'*, *c'*, *d'*) so that the curvatures of the terminal portions of the asci may be seen. The shaded portion is the hymenium, consisting of asci and paraphyses.

formed at right angles to the hymenial surface and normally are thus parallel with the incident light. But here the apothecia were receiving only unilateral illumination, so that in the very young cup-like stages and on the revolute margin of older ones, the terminal portion of each ascus, containing the ascospores, curved so as to become parallel with the incident light (Fig. 2 *b* and Fig. 3): sometimes the portion of the ascus which curved

was quite short, only two or three ascospores being included (Fig. 2 *a* and *c*.)

Many of the fruit-bodies attained a large size (diameter 8 to 10 cm.) and then the hymenial surface became very uneven and the margins very revolute, so that the discs, which when young were flattened and had their whole surfaces at right angles to the incident light, now, because of unequal growth or pressure of neighbouring fruit-bodies and substratum, could not retain the original position, and it was chiefly by heliotropic curvatures of the asci (Fig. 2 *a*, *b*, *c*) that suitable adjustment to the light was attained.

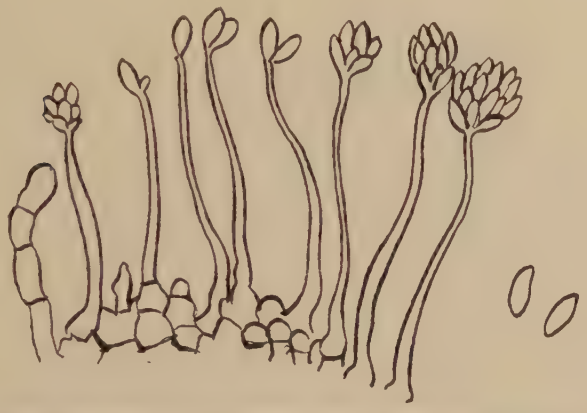

Fig. 4. *Aleuria repanda*. Condiophores with clusters of conidia. Note the conidiophores are extended cells of the excipulum. × 900.

(2) A Conidial Stage.

While examining the fruit-bodies of *Aleuria repanda* I found a conidial stage of the fungus. The exterior of the fruit-bodies is usually very granular, but many of the very young apothecia and those about two-thirds grown looked particularly mealy. This was due to conidiophores bearing clusters of conidia which in general appearance under low magnification suggested a minute white *Aspergillus*. The conidiophores were aseptate and unbranched and arose as tapering filamentous extensions of some of the cells of the pseudo-parenchymatous excipulum. Each conidiophore bore a head of conidia, which were loosely attached by minute sterigmata. The conidia, which were colourless, aseptate, oval, and measured 12μ × 4μ, were produced in such profusion that, although some were pushed off their sterigmata by the

growth of neighbouring ones, they adhered in clusters of ten to twenty or more.

Brefeld[1] describes a conidial stage of *A. repanda* which he obtained in cultures from ascospores. The conidia agree in size and shape with those described above, but the conidiophores were branched and conidia were produced in clusters on inflated ends quite unlike the simple tapering conidiophores which developed on my specimens.

A NOTE ON THE "BUD-ROT" OF APPLE TREES.

By W. A. R. Dillon-Weston, M.A.

In recent years apple trees have been attacked by a disease of the flower buds which causes the unopened bud to rot upon the trees, a disease known by fruit growers as "Bud-rot."

The chief symptom to be observed in the orchard is the failure of the bud to open, but later in the season a weft of salmon-pink mycelium may generally be found between the bud scales, and microscopic examination shows mycelium and conidia of a species of *Fusarium*: bacteria also may be present. The conidia are curved and pointed but their size and septation are variable.

The literature of this disease is of recent origin. According to Kidd and Beaumont (1) Bud-rot was first recorded by Wiltshire (2) in 1914 but this would appear to be incorrect, for a note by Salmon and Wormald on "A New Disease of Apple Buds" (3) was published in 1912. The spore measurements there recorded were 25–35 μ × 3·5–4·5 μ, and the conidia were curved, pointed and usually 3-septate.

Spores which I examined taken from diseased buds in May 1925 were pointed, cylindrical 3–6-septate and varied from 24–40 μ × 3·5–4 μ.

Kidd and Beaumont in describing *F. fructigenum* occurring on apples in storage suggested that the fungus was identical with that causing Bud-rot. They describe *F. fructigenum* as being a vigorous parasite, with conidia 30–45 μ × 3–4 μ, and 3- to 7- usually 5-septate.

[1] Brefeld, Mycol. Unters. IX, Table III B, Figs. 32–41; X, p. 336.

Aderhold (4) attributed the disease to *Fusarium gemmiperda* n.sp., and it is interesting to note that the Dutch have stated that *F. gemmiperda* is associated with a disease of pear buds in Holland.

The question then arose whether *F. fructigenum* or *F. gemmiperda* was to be considered as the causal organism, and seeing that Wollenweber did not deal with *F. gemmiperda* in his *Fusaria Autographice Delineata*, I sent him a culture of the fungus causing Bud-rot and some fresh material for his opinion.

The following is an extract from his reply:

"...the pure culture of the fungus sent for comparison appears to me to contain *Fusarium fructigenum* (Fries). I obtained typical sporodochia after inoculating your fungus on lupin stalks. On this substratum, as well as on oatmeal Agar, they were on the average somewhat larger and more septate than you state in your letter, namely 90 % 5-septate and 40–60 μ × 3–3·5 μ. There was a lack of typical blue-black sclerotial stroma which is characteristic of *Fusarium*. I therefore isolated the fungus from the natural material sent by you and obtained therefrom apparently the same fungus differing however by numerous sclerotia which appear to be lost again by the further transference of ripe conidia ('die sich bei weiterer Übertragung reifer Konidien wieder zu verlieren scheinen'). The conidia of this second culture correspond with *F. fructigenum* (Fr.) in size and septation. The already mentioned small differences in the behaviour of the pure cultures in the various isolations and parent samples are morphologically of no great importance, although they, as shown by the work of Brown and Horne, show a certain constant uniformity ("eine gewisse Konstanz zeigen"). One could therefore identify the fungus just as well with *F. Blackmanii*, if this kind is uniform. On the other hand there is no reason to renounce the name *F. fructigenum* given by Fries. I have so far found the fungus on *Pyrus*, also on *Cydonia* and *Rosa* fruits and on leaves and branches of *Taxus* and branches of *Sambucus*. It is also identical with the *F. cydoniarum* Roum. which Fautrey collected from rotting quince fruits in 1889 and described the conidia as being 5-septate 40–45 μ × 4 μ. Further it is probably identical with *F. gemmiperda* Aderhold, almost certainly, although I did not make a full examination of Aderhold's fungus I had the impression it was the same as *F. fructigenum*...."

In the Isle of Ely Emneth Early is the variety of apple tree most susceptible to this disease and during the spring of 1925, 30–50 per cent. of the buds were sometimes affected. Lord Grosvenor also is attacked very severely, Grenadier less severely, Lane's Prince Albert and Lord Derby moderately, and Bramley's

Seedling, Newton Wonder and Worcester Pearmain slightly. The climatic conditions that favour the intensity of this disease appear to be a wet summer and autumn, because following the wet summer and autumn of 1919 and 1924 there were severe attacks of Bud-rot in the spring of 1920 and 1925. The dry summer of 1921, however, considerably checked the disease.

I wish to thank Dr Wollenweber for his most careful diagnosis, Mr Wiltshire for supplying certain references to the disease, Dr H. E. Woodman, and Mr J. C. Ward.

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STUDIES ON PODOSPHAERA LEUCOTRICHA (ELL. & EV.) SALM.

I. THE MODE OF PERENNATION.

(With Plates XVI, XVII and 1 Text-figure.)

By R. C. Woodward, B.Sc., Ph.D. (Cantab.),
School of Rural Economy, Oxford.

Introduction.

Apple mildew, *Podosphaera leucotricha*, has been an orchard pest for many years but of late, owing to its greater intensity of attack, which has perhaps been made more apparent by the recent impetus given to the apple growing industry, it has become, in England, a factor of great economic importance. In consequence a reinvestigation of parts of its life-history relating to its continual reoccurrence, and more detailed observations upon the method of parasitism of this extremely widespread disease were undertaken. The fungus has been repeatedly studied, especially on the Continent and in America. Seasonal epidemics occur regularly and do considerable damage in spite of the adoption of repressive or exterminative measures. It was hoped that a detailed investigation of certain problems connected with the disease might lead to a more intelligent application of controls and throw light upon the reasons for the failure of combative measures.

The means by which the fungus perennates has not received in this country the attention which it has deserved. To establish irrefutably the mode of perennation under English conditions was one of the principal objects of these investigations. The greater part of the work has been carried out at the Botany School, Cambridge, and the remainder at the School of Rural Economy, Oxford. The research was suggested by Mr F. T. Brooks for whose unfailing help and inspiration the writer is greatly indebted.

Apparently the first reference to perennation of the mycelium of apple mildew was made in Germany in 1889 when Sorauer (37) reported the perennation of mycelium of *Sphaerotheca Castagnei* Lév. on young apple shoots; no other specific information, however, was given. In the same year Galloway (12), in America, reported perennation of apple mildew in mycelial form. Perennation of the fungus through the agency of buds was first reported by Tubeuf (38) in 1910, but no proof was given for the assumption that mycelium existed in the closed bud. In 1921

a record of hibernation of apple mildew by means of the bud was made by Van Poeteren* (25) in Holland, who investigated the mildew on oak and found that its method of perennation was similar to that of the mildew on apple. In both fungi the existence of an overwintering mycelium between the bud scales was assumed. The infestation of buds was indicated by the presence of mildew conidia on young leaves which developed from these buds in spring. He found it hard to believe that all buds on the twig would not be attacked indiscriminately if the disease spread from an outside source, and was led to conclude that mycelium was the probable hibernating body because conidia, according to Neger, do not survive the winter. Observations in America by Ballard and Volck (1) suggested similar means of perennation. In 1918 Fisher (9), in describing an attacked twig, wrote, "Buds formed are infected by the overwintering mycelium and in the spring the fungus resumes activity when the leaves unfold." Höstermann (15) presented strong circumstantial evidence of mildew perennation in buds in 1922. He gathered apple twigs in the winter, brought them into a greenhouse, and sprayed them with various fungicides but found that the buds, on opening, were infected with mildew. This investigator suggested mycelium in the buds as the overwintering agent. In support of the view that *P. leucotricha* might tide over the winter in dormant buds Foëx (11) in 1923 cited Chabrolin's observations on two young apple trees. It was noted that on the opening of the buds the disease spread from the base of the petiole towards the apex of the leaf blade; this, he observed, would suggest that the fungus had overwintered in a still unknown form under the leaf scales in the buds.

It may be said that the records of past investigations have revealed only a superficial knowledge of the perennation of this fungus.

Perennation by Bud Infestation.

The Time and Method of Bud Infection.

Axillary buds of the apple become infected a full season before opening. Entry is effected at an early stage in bud development. Soon after the new shoot is put forth in spring and leaves are developed thereon, rudimentary buds are produced in their axils which, at the time of infection, are often hidden by the leaf stalks (Pl. XVI, fig. 1), which must be detached to allow inspection. Covered with many hairs, the undeveloped buds present a fluffy appearance and are much flattened, due to the

* I wish here to express my thanks to Dr Van Poeteren for a copy of this paper and to J. L. Steenkamp, Oxford, for his help in translation.

confined growing space. Two bud scales may be seen to be wrapped rather insecurely around the bud, enveloping the base but leaving the apex loosely clasped. The scales, which are easily removed, are found to overlap considerably at the foot of the bud but often leave a gap at the tip, thus providing a point of access for the mildew.

The hyphae responsible for invasion are derived from mycelium established on the young shoot. The tender tissue of the shoot provides a nutritious substratum for the fungus which confines itself mostly to vegetative growth, and soon enmeshes its host with a tangled mass of hyphae. It is not long before the axillary buds are reached and in the absence of adequate protection by the scales at this stage of development, the hyphae enter and become established between the tissues within.

Besides axillary buds, fruit buds on the terminals of spurs are infected. At an early stage the infecting mycelium, derived from the infected fruit bud immediately preceding and adjoining the rudimentary bud, becomes established and is able to invade the tissues within the immature bud because of the inadequate protection afforded by its undeveloped bud scales; here the mycelium perennates until the bursting of the bud. Occasionally secondary infection occurs, *i.e.* an infection of a healthy spur or shoot is brought about by conidia from neighbouring sources. In all bud infections the perennating mycelium becomes established within the tissues early in the season; later penetration is prevented by bud scales.

The Distribution of Hyphae within the Bud.

On teasing apart the enveloping scales a mycelial plate composed of numerous interlacing hyphae may be seen on their inner surfaces. The mycelium is more abundant on the apices of the inner scales where the tissue is not so cuticularised and may be traced between the enclosed softer rudimentary tissues. Transverse median sections through such buds reveal mycelia between all the composing elements. Pl. XVII, fig. 1, shows a median section* through an axillary bud on one-year wood of Cox's Orange Pippin and illustrates the relative distribution of the mildew mycelium. Mycelium is also abundant between the bud scales, but on the approach of winter that nearer the exterior of the bud loses its vitality, whereas the mycelium between the inner tissues retains a healthy appearance throughout the winter. The tissues in the young bud are not so tightly

* The section illustrated was cut through a bud gathered on January 3rd. All the cuticularised bud scales were removed before fixing the material in order to facilitate thorough and rapid penetration.

compacted that they preclude meandering hyphae and, being tender and somewhat sappy, provide adequate organic material to sustain the fungus. As the season advances the buds swell and, becoming ensheathed by additional bud scales, are soon completely enclosed. By this time the mildew has completed its seasonal growth and, with the bud, remains dormant throughout the ensuing months until spring.

Monthly examinations of dormant buds and a series of transverse sections have shown the distribution of the fungus within them throughout the winter. The state of the nuclei, and the normal, healthy appearance of the hyphae show that the fungus is maintained in a living condition (Text-fig. 1). As mycelium becomes established within the buds in spring, soon after the trees are in full leaf, and is stimulated into growth again at a little earlier period, *i.e.* at bud-break the following season, the period of perennation is roughly eleven months.

The presence of haustoria in the leaf tissues enclosed by the bud scales from the time of initial hyphal invasion until the reawakening of the fungus to activity in the spring, presents a means for the immediate identification of the mycelium and provides a method by which the fungus may perhaps be maintained in a living condition. That haustoria play a vital part in perennation seems very probable. No thickening of the hyphae of *P. leucotricha* in infected buds has been observed nor anything which suggested the occurrence of chlamydospore-like bodies as recorded by Ferraris (8) and Petri (24) in *Microsphaera quercina* and by Foëx (11) in *Uncinula necator*, and other Erysiphaceae. It is improbable that hyphae of an obligate parasite, after remaining dormant over long periods, could reawaken into vigorous growth in the absence of some such type of organ or without some means whereby direct stimulation might be received from the host. Mycelium between the outer scales of an infected bud perishes, as also does that on the toughened outer tissues of an infected shoot and it can hardly be doubted that here the haustoria have been put out of action by the hardening of the tissues. Frequent attempts were made to stimulate into growth mycelium on twigs infected the previous season. Inoculation trials on young leaves, using such mycelium, were unsuccessful. An infected twig brought into the laboratory in September was allowed to stand in water for ten days at a temperature of 60–65° F., after which it was kept in a moist atmosphere under a bell jar. A few conidiophores were produced from the mycelial matting. At this time the outer tissues of the twig had not completely hardened off. It is doubtful if death of the exposed mycelium is due to low winter temperatures. Westerdijk (41) has observed that mycelium which is found during winter on peach twigs

does not develop in spring, but Salmon (29), on the other hand, found that conidiophores were produced from patches of mycelium of *Oidium Euonymi japonici* when leaves of *Euonymus* were placed in a damp Petri dish in April and May and again in December. Where, however, the host does not harden, the haustoria probably retain their function and only await stimulation from the host to regain activity. This assuredly seems

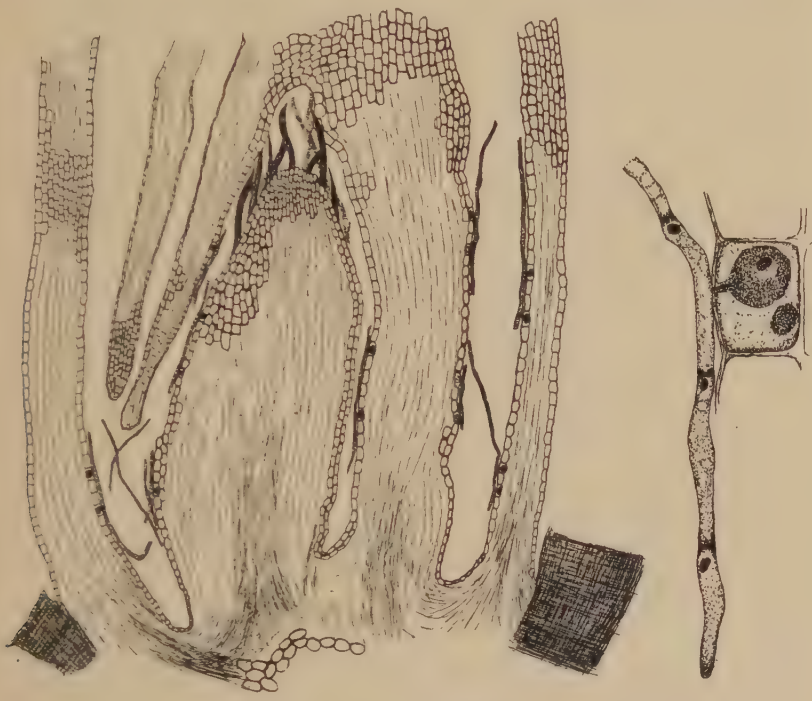

Fig. 1. Diagrammatic drawing of portion of median section through infected axillary bud of Cox's Orange Pippin gathered in January showing normal hyphae and haustoria × 40: on the right a portion of the fungus × 500.

so with haustoria in the tissues of dormant apple buds infected with *P. leucotricha*.

Text-fig. 1 illustrates mycelium and haustoria in an axillary bud of Cox's Orange Pippin taken from one year old "wood" on January 3rd, 1925. The haustoria to which the hyphae are attached appear normal and apparently retain their function through the winter. It will be apparent that with host and parasite in such close and intimate association the parasite will be stimulated into growth as soon as sap is supplied to the

tissues in spring when the buds swell. This is borne out by the actual formation of conidiophores in closed buds.

The Formation of Conidiophores within Closed Buds.

A number of twigs of Fearn's Pippin were gathered on March 7th, 1924, in order to investigate the distribution of hyphae within the buds, and allowed to stand in water in the warmth of the laboratory for four weeks until the buds began to swell: these were excised for examination when a green tip began to protrude between the scales. The tissues of the bud were then teased apart gradually. An axillary bud on "one-year-wood" near the tip of the twig showed no fructifying mycelium on the two outer layers of scales but conidiophores bearing apparently normal conidia were present on the rudimentary leaf tissues. The fungus was fructifying freely on the young leaf-stalks and was producing conidia on them throughout their length to the point of attachment at the base. Chains of conidia occurred on quite tightly folded rudimentary leaves, in the centre of the closed bud; the young leaf-stalk seemed most favourable for their production.

Subsequent observations on buds under outside conditions have often revealed the same phenomenon. Dispersal of conidia may take place at any time during the bursting of the buds; all that is awaited before liberation is the separation of the immature leaves and the unfolding of the buds.

In severe twig infection the buds not killed are often so thoroughly permeated by the fungus that they are much weakened. The portions which suffer most are usually near the tip; the uppermost fringes of the rudimentary leaves turn brown and die (Pl. XVII, fig. 1). Axillary buds on "one-year-wood" are so incapacitated that their growth is checked and the date of opening is delayed compared with their mildew-free neighbours, and this provides a ready means by which infected buds may be detected. It is near the region of killed tissue at the apex of the closed bud that hyphae are as a rule more plentiful, evidently because the mycelium entered the bud first at this point.

In those portions of the infected tissue which have not become definitely brown the epidermal cells invaded by haustoria contain a substance which forms a dark-coloured inner lining to the cell. Definite barriers are thus formed which cut off the haustoria from organic food material; at a later stage, when the tissue has become definitely brown, the haustoria succumb; the epidermal cells shrink and become filled with dark-coloured oily or gummy globules.

On the Distribution on Affected Trees of Buds containing Perennating Mycelium.

The distribution of infected buds on the tree may more easily be studied at two periods; in the autumn when the leaves have fallen and in the spring when the mildewed buds are opening. In autumn their distribution is evident by the whitened appearance of the twigs which have been attacked and, where perithecia occur, by black masses of these bodies on the current season's growth.

It is in spring when the buds burst that the distribution of mildew may be most easily observed by a slightly distorted or stunted appearance of the opening bud and the appearance of conidia on the green leaf tissue protruding from the enveloping scales. Furthermore, the cutting at any time of sections through suspected buds provides a certain method of discovering infection. By utilising these methods the distribution of buds containing viable mycelium or haustoria has been studied. The most frequently infected are axillary and terminal buds on "one-year-wood." When infection is severe terminal buds are killed by the fungus with the consequent death of the mycelium. Indeed, many of the axillary buds on the affected portion of the twig also perish. When infected parts are killed outright, the fungus defeats its own end by depriving itself of living host tissue essential to its existence. Occasionally, when branches are killed back, dormant buds are stimulated into growth on "two-year-wood" and in them the hibernating mycelium which entered when the buds were formed is stimulated into growth. Here the mycelium and haustoria must have remained dormant in the buds for two seasons.

Next in importance to terminal and axillary buds in harbouring the disease are blossom buds on the terminals of fruit-spurs. Such buds may usually be detected in autumn and winter lower down on the same branch as that which bears infected "one-year-wood." The peculiar enamelling effect produced by mycelium on spurs near the base of such buds is sometimes quite marked.

To determine the approximate percentage of mildewed twigs which eventually produced mildewed buds, twigs marked the previous autumn as being attacked by the fungus were gathered in late winter and were allowed to stand in water in the warmth of the greenhouse. Care was taken to remove all perithecia. Infection by wind-borne spores could be safely ruled out because buds produced in the open were dormant at the time of these observations. One hundred and fifty twigs of Fearn's Pippin and fifty of Allington Pippin were kept under observation.

Only forty to fifty per cent. of the twigs visibly attacked by mildew bore buds which opened in an infected condition. Of these buds the terminal, whether blossom or leaf bud, was as important as axillary buds in perpetuating the disease. When the disease first made its appearance it was usually limited to one bud per shoot, more rarely to two or more buds. These observations apply to standard trees of twelve and fifteen years of age but observations on other varieties of various ages indicate in general a similar distribution.

The Association of Mildew with the Development of Shoots from Mildew-infested Buds.

Young shoots of apple become infected at a very early stage in their development, as they arise from infected wood buds or blossom buds. Blossom buds of the apple contain leaves and an embryo shoot in addition to flowers, and differ from peach and plum in being thus provided with a means for further growth at this point. This peculiarity of growth particularly favours the perpetuity of the fungal parasite. On the bursting of the blossom bud the perennating mycelium fructifies freely and attacks its host during all stages of growth (Pl. XVI, figs. 2, 3 and 4). The blossoms are often entirely destroyed and the foliage stunted and contorted. The embryo shoot is soon produced and, as it is in close contact with infection, falls a direct prey to the mildew, and the axillary buds are then invaded.

Perennation by Perithecia.

Notes were kept on material bearing perithecia at: University Farm, Cambridge, twelve trees Lane's Prince Albert; Meldreth, Cambs., twelve trees Fearn's Pippin and twelve trees Allington Pippin; Evesham, about 150 trees of the varieties Early Victoria, Beauty of Bath, Lord Derby and Cox's Orange Pippin. Twigs which bore perithecia were marked early in the autumn and were brought in, a few at a time, continuously until June 8th (for the season 1923–1924). During the season 1924–1925 observations were confined to trees at Cambridge and Evesham until the first outbreak of the disease in spring. During the season 1925–1926 observations were concentrated at Cambridge throughout the same winter period.

The Date of Formation, Incidence, and Time of Duration on the Host.

Perithecia of *P. leucotricha* are by no means scarce, especially on certain varieties of apples. Mature perithecia may be observed as early as May and the appendages of many of the earliest fructifications are fully developed by June. The period

in which perithecia are produced extends well into the summer; freshly formed fructifications may be observed in July and August and may easily be distinguished at this time from the more mature, darker perithecia by the lightness of their colour. On strong-growing twigs, perithecia usually persist throughout the winter months. When a twig is killed, perithecia rarely remain on the host because the mycelial matting peels off, and in doing so they are carried with it. Peeling of mycelial matting often occurs to a limited extent on the central area and towards the extremities of strong-growing, infected shoots; a considerable number of fructifications, however, are almost invariably retained at the base of the area of infection.

Perithecia are produced on: (1) Current season's growth and, on rare occasions, farther down on the same shoot on "two-year-wood" immediately below the junction of the two seasons' growth. When produced on the current year's "wood," which is the normal position, they are usually more dense on the lower part. (2) "Sucker" growth arising from older branches on the lower part of the tree. Not infrequently a shoot thus infected is blackened by dense masses of perithecia. "Sucker" shoots are normally much longer than the infected terminals and are often covered throughout their length by the fructifications which, when congregated into patches, give the shoot a mottled effect. (3) The leaf-stalk, midrib and the larger veins of infected leaves.

Perithecia are said to have been observed on the fruits themselves, but I have not seen any.

External Morphology and Position on the Substratum.

Soon after formation the perithecia are globose in shape, and retain their conformity throughout the greater part of the summer. During September fully seventy-five per cent. of perithecia examined were markedly depressed in their upper surface (Pl. XVII, fig. 2). A very small percentage of perithecia were found without depressions but these were usually smaller in size and suggested an immature condition through later development. The apical appendages arise, as a rule, from the depressed portion of the perithecium. Occasionally the depression occurs on the side of the perithecium and may be observed in the same plane as the basal and apical appendages.

To investigate these concavities, perithecia were subjected in October to a saturated atmosphere under a bell-jar for ten days. No change in the position of the perithecia could be observed; the concavities were as numerous as they were previously. In other trials perithecia were subjected to a saturated

atmosphere in a Van Tieghem cell and in a Petri dish on their original substratum, but their shrunken condition was unaltered and their respective positions unchanged. Similar trials were continued in November but without success. In February further experiments yielded negative results, although at this time tap water was frequently sprayed upon the perithecia by means of an "atomiser."

It was thought that the depressions mentioned might have something to do with detachment from the substratum. Neger (19) found the wall of the perithecium of *Erysiphe graminis* and more markedly that of *E. taurica* composed towards the exterior of several layers of very strongly thickened cells. He found the layers of thick-walled cells more numerous on the upper side; on loss of turgescence, the perithecia became slightly concave on the upper surface. *Microsphaera* showed the reverse condition, *i.e.* on the lower half were thin-walled, flexible cells which became depressed and formed a concavity on the lower surface; *Podosphaera* showed similar structure. In classifying the genera according to the detachment mechanism of the perithecia, Neger placed *Podosphaera* in the group in which perithecia fall off when ripe, the detachment being caused by the shrinking of the perithecium base due to the presence there of more delicate cellular formation. I am unable to agree with Neger in regard to the position of the depression for, as already pointed out, the perithecia of *P. leucotricha* are concave in the upper half. Further, because of the position of the depression, it is difficult to imagine that it can have anything to do with detachment as it is obvious that the filling out of the upper half of the perithecium would not bring into play any displacing mechanism. Moreover, the writer found that the perithecia of *P. leucotricha* were normally retained by their host both on twigs brought into the laboratory and on trees in the plantation. In this connection special note was kept on thirty-five twigs of Lane's Prince Albert bearing perithecia, in order to learn whether the latter were naturally shed at any time. When observations were begun in August perithecia were plentiful; by October their number appeared to have increased. This augmentation was probably due to the ripening of some of the less mature fructifications. By November perithecia were abundant on seventy-five per cent. of the twigs under observation; on the remainder their number had decreased and, in a few cases, were absent. After this date they remained constant throughout the winter. In the few twigs noted in which the perithecia were shed, peeling of the mycelial matting from the host was observed. Further observations were kept on thirty-six twigs of the variety Mr Gladstone at Evesham upon which

perithecia were observed in September. By January 31st only three were without perithecia; the remainder had a plentiful supply which were still present at the end of February.

The perithecium is attached to the substratum by the basal appendages which are short and tortuous. The apical appendages are long, slender, stiff and taper characteristically to rather a blunt point. Salmon has described the apices of the appendages as "rarely once or twice dichotomously divided." During observations carried on for three years on numerous perithecia in all stages of development I have seen only two examples of this and have been unable to find septa in young or old appendages as recorded by this author, and more recently reported by Cunningham (7) in New Zealand. The number of apical appendages varies greatly; often they are absent, due to falling off or non-development. As many as ten may be counted sometimes and when a great number of perithecia is aggregated in dense masses the erect appendages give these dark blotch-like congregations a very characteristic, bristly appearance, which suggests a capacity for collection and retention of the moisture essential for germination purposes. The original specific use of these organs or their present use is a matter for conjecture, but it is difficult to imagine that they could play a part in the detachment of the perithecium as do those of *Phyllactinia*, although it has been noted that when globose perithecia are placed in water and swell slightly before rupturing the apical appendages spread themselves in a fan-like manner.

The Method of Dehiscence of the Ascus and Ejection of Ascospores.

The perithecium is a true cleistocarp, the ascus being ejected through an irregular rupture of the wall. The split usually occurs at a slightly oblique angle to the base separating, at times, the apical appendages situated in the equatorial region from those nearer the apex. The opening formed gradually widens owing to the expansion of the ascus following the absorption of water. Harper (14) has suggested that the cells of the inner wall of the perithecium of *Sphaerotheca Castagnei* permanently retain their nuclei and may produce a substance capable of swelling in water which would cause the rupture of the wall. Because of the absorptive capacity of the ascus and the great force it would be capable of exerting on the perithecial case, Harper's assumption seems unnecessary to explain this phenomenon in *P. leucotricha*. The perithecial wall is elastic and responds to the pressure exerted from within until the opening, although of smaller diameter, can no longer restrain

the ascus which squeezes through the orifice and is violently ejected. The force of ejection is considerably increased by the snapping together of the "jaws" of the orifice due to the elasticity of the perithecial case. Occasionally the ascus is not emitted but ruptures within the perithecium and the ascospores are then liberated through the orifice in the perithecial wall. As a rule, however, the ascus is ejected intact with subsequent rupture of the ascus sac and liberation of ascospores; when this occurs the ascus is often thrown several cm. in the air. On reaching water, or in a damp atmosphere, it continues to swell and within one or two minutes explodes, scattering the ascospores in all directions. The wall of the ascus of *P. leucotricha* is of the same thickness throughout and no "pore" has been observed near the apex as Salmon has described in *Sphaerotheca Humuli* (30) and *S. mors-uvae* (31). The split occurs in the apical region and the opening is quite conspicuous in a shrunken ascus which has been emptied of its contents.

A Van Tieghem cell was used for the examination of ascus dehiscence. The material under observation was placed on wet blotting paper and was enclosed by a glass ring so as to support over the material a small drop of water on the under surface of a coverslip which was used to catch the ejected spores. Both ascus sacs and ascospores were shot on to the coverslip. In other trials in which perithecia were placed in a hanging-drop the gradual splitting of the perithecial wall and emission of the ascus could be minutely observed. Ejection of the ascus on to the coverslip occurred only in one lot of material from Lane's Prince Albert. Ejection of asci took place during the week February 7th to 14th, 1924, on material from two only of all twigs under examination. On placing mature perithecia in a hanging-drop ascus emission took place after three minutes' immersion and two minutes later the ejected ascus liberated its ascospores. In subsequent trials the perithecial wall ruptured after five minutes' immersion but no asci were emitted until six hours later. By this time a number of other perithecia had ruptured but nearly all retained their asci and ascospores. Other perithecia ejected their asci after three hours' immersion while others, in the same hanging-drop, only showed a preliminary split by this time. It seemed evident from these trials that maturity of the perithecium is a factor controlling rapidity of dehiscence. A great number of trials, continued through February and March until the disease was evident on the opening buds, yielded only one additional instance of ascus emission; the ascus sac, however, did not liberate its ascospores.

During these experiments no ready means for detecting a viable perithecium was discovered. For instance, in an ex-

amination of seventy perithecia of which the greater part appeared globose and of a healthy, dark brown colour, only three contracted a preliminary rupture, none emitted asci. But the general shrivelled condition of the greater number of these perithecia was forcibly brought to my attention.

The Function of Perithecia and Comparisons with other Erysiphaceae.

On account of the shrivelled condition of the majority of perithecia from September onwards and the apparently non-viable condition of the remainder it is impossible to ascribe to them any function in the life-history of the disease.

Galloway (12) in America first suggested the unimportance of the sexual form of *P. leucotricha*. Some time later Ballard and Volck (1) in California came to the same view. In 1918 infection trials with ascospores were undertaken by Fisher (9) but without success. This investigator assumed that the "ascospores play little, if any, part in spreading the disease and that they are unnecessary to the overwintering of the fungus." To establish the part played by perithecia under English conditions, records were kept by the writer over the seasons 1923–1924, 1924–1925, 1925–1926.

Perithecia in their natural habitat on infected twigs were kept under close observation in various localities, and in the laboratory, from development to maturity and final collapse and disintegration. Ten varieties in representative apple growing districts were kept under observation. All trials emphasised the non-viability of the ascospores and, except for the one instance previously mentioned, the non-ejection of asci.

To learn whether perithecia on leaves which fell in autumn provided a source of infection in spring, the following observations were made. Fifteen leaves gathered from Lane's Prince Albert trees at Cambridge University Farm, with a copious supply of perithecia on the midrib and leaf-stalk were placed, in August, in an exposed position in the open but protected from the wind by netting. By October 20th the leaves with the accompanying ascogenous form of the fungus had disintegrated. None of the perithecia on the leaves survived. Although some might have fallen on the surrounding soil, it appeared very improbable that any retained their viability until spring. No definite conclusions can be drawn but evidence seems against retention of viability by such perithecia.

The examination of perithecia from the various sources named revealed: (*a*) a collapsed condition; (*b*) loss of texture in the perithecial wall; (*c*) undeveloped, abnormal ascospores and (*d*) an extraneous fungus within the perithecium.

The collapsed condition of the perithecia has already been discussed. The fact that perithecia do not regain their normal shape when subjected to a saturated atmosphere indicates loss of vitality. Throughout the winter months and in spring the collapsed perithecia, or those which had retained their original globose shape, crumbled when crushed in water under a coverslip in a manner which suggested their lifeless condition. Normally, ascospores are fully formed before the end of the summer. By September or a little later, when the upper half of the perithecium becomes depressed, the ascospores are small and the ascus appears shrunken when pressed out, and does not swell on immersion in water. Spores of an extraneous fungus were not infrequently observed in perithecia*. Upon pressing, a stream of non-septate spores was emitted but, when the perithecia were allowed to remain in water, saprophytic hyphae soon grew out from the periphery. Common moulds and Mucors often developed. A parasitic attack by such fungi seems improbable. During the summer months until September these fungi are not in great evidence; it is only after shrivelling that they become increasingly evident. In the light of repeated observations, no other assumption can be entertained than that they are saprophytic organisms. Salmon (28) has observed that sometimes when perithecia of mildews (not apple mildew) are crushed a stream of very small biguttulate spores of *Cicinnobolus Cesatii* de Bary, 6·5 to 10·5 $\mu \times 3{\cdot}5$ to 6 μ, immersed in a colourless, mucilaginous substance is emitted. There may be found on the same mycelium smaller bodies oval to pyriform in shape without appendages and containing the same kind of spores. Such pycnidia have been found in association with mildew hyphae in the vicinity of parasitised perithecia of *P. leucotricha* but no pycnospores were observed within them. No signs of the parasite have been observed in the conidial stage of *P. leucotricha*. In order finally to establish the identity of the spores emitted from perithecia of *P. leucotricha* further corroborative observations are necessary.

Comparatively little is known of the part played by perithecia in the Erysiphaceae. Salmon (31) has made observations on *Sphaerotheca mors-uvae* of which he found mature perithecia in August which, he thought, had spread the disease that summer. He found that some perithecia gathered in November emitted ripe spores when moistened in February after remaining dry at 15° C. in the laboratory through the winter. On the other hand, perithecia exposed on the bush through the winter

* Prof. Salmon, to whom the writer is much indebted, has kindly examined microtome sections of perithecia attacked in this way and has suggested parasitism by *Cicinnobolus*.

did not show any mature asci in February. The probability is mentioned that those perithecia which reach maturity early fall to the ground and may be responsible for spring infection. The improbability of this in *P. leucotricha* has already been pointed out. In *Erysiphe graminis* Salmon (32) found that when perithecia were kept dry in a box in winter, ascospore production could be started at any time by moisture. He found that the ascospores germinated in water, with the production of germ tubes from both ends of the spore. Galloway (13), in his observations on *Uncinula spiralis*, found that one of the first changes in the appearance of perithecia in the winter was the gradual disappearance of the appendages. By the end of December he found that many of the asci were dead or collapsed and that germination of ascospores could not be induced until February and then only after many trials and the exercise of great perseverance. A large part of the spores burst as soon as they were free from the asci. In bursting, the spores scattered the walls and contents in all directions. Ascospores of *P. leucotricha* which were of normal size and were naturally ejected occasionally behaved similarly when allowed to remain in water; however, no sudden bursting occurred, but the wall of the ascospore split and the spore contents were emitted in a stream, while the ascus sac gradually collapsed.

Factors influencing the Formation of Perithecia.

Neger (22) has suggested that "La formation des périthèces implique un milieu nourricier âgé (adulte) non encore épuisé par la production de conidies." My observations hardly suggested these conditions; the development of perithecia was observed as early as May on young growth: dryness sometimes favours their production. *Erysiphe taurica* produces perithecia on *Phlomis Herba-venti* when the leaves dry, but *Microsphaera quercina* produces them more often in shaded spots than in the open. Bioletti (3) has observed that warm, moist weather favours luxuriant mycelial growth in *Uncinula necator* and if followed by a sudden lowering of the temperature to about 50° F. the formation of perithecia is speedily induced.

One of the more important conditions which favours the production of perithecia in *P. leucotricha* is severe hyphal infection of the shoot in a young stage. Perithecia are uncommon where the fungus has not previously obtained a firm footing accompanied by a thick coating of mycelium; the early and vigorous infection of certain shoots is often followed by perithecial development. "Sucker" shoots become thoroughly parasitised at an early stage and perithecia are usually copiously produced. Examinations made through the spring and the summer

for the presence of perithecia on the current season's growth revealed the fact that they were present on only a limited number of infected twigs on each tree. Shoots without perithecia had not often suffered a severe hyphal attack. Varietal susceptibility to mildew may in this way be a factor limiting perithecial production. Severely infected varieties such as Lane's Prince Albert bear numerous perithecia, whereas many of the more resistant varieties bear perithecia only sporadically. Occasionally the soil or other environmental factor may break down the resistance of a host and the shoots suffer in consequence an early and severe infection followed by production of perithecia.

II. OBSERVATIONS ON SOME HOST-PARASITE RELATIONSHIPS.

I. The Conditions for Germination of Conidia of *P. leucotricha*

The conditions necessary for germination of conidia of *P. leucotricha* have received little attention by past investigators, but many investigations have been made on other Erysiphaceae. Morgenthaler (18) found that *Oidium Tuckeri* thrived at 5–10° C. and had an optimum temperature for growth at 25-30° C. Rauch (26) found feeble germination in *Sphaerotheca pannosa* at 6–8° C., a good germination at 12° C. with an accelerated growth at 17–30° C. In *Sphaerotheca Humuli* on strawberry, Salmon (30) found feeble germination when conidia were sown in hanging drops at the ordinary temperature; after a preliminary subjection to 0° C. germination was greatly increased. Voglino (39) found that conidia of *Phyllactinia corylea* germinated between 4 and 35° C. but died regularly at 0° C. This author also found that the optimum temperature for the production of conidia on leaves was between 18 and 25° C. Germination in *Erysiphe graminis* according to Rivera (27) was inhibited at 29 and 30° C. and death occurred at a higher temperature. Schaffnit (35) has obtained germination of the conidia of this fungus after subjection for six to eight hours to a temperature of −17° C. There is thus a wide range in the temperature requirements of mildews.

During observations on conidia of *P. leucotricha* during 1924 and 1925 unknown factors which inhibited germination were encountered. On February 23rd, 1924, conidia gathered from breaking buds of Fearn's Pippin "forced" in the laboratory were set up in a hanging drop preparation but did not germinate. Again, on April 4th, conidia from Cox's Orange Pippin similarly produced were sown in water in a watch glass but no germination took place.

Subsequent trials in watch glasses and hanging drops, on April 12th, also proved unsuccessful. On April 14th, in similar preparations, slight protuberances were noted in certain conidia accompanied by the shrinking of their contents. On April 27th, after 40 hours, a very small percentage germinated on the surface of tap water and on the moist surface of the watch glass containing it. On May 6th a feeble germination was again obtained although a previous trial, on May 2nd, yielded negative results.

In the following year the percentage germination was sampled during the period of conidia production in the plantation. The conidia were sown in drops of water on ordinary microscopic slides which were then placed on damp blotting paper in a moist atmosphere provided by a bell-jar lined with moistened filter paper. From May 2nd to the 7th a series of five separate preparations, in which eleven hundred and forty-two conidia from Fearn's Pippin were kept under observation, yielded an average germination of two to three per cent. In another series of trials from May 9th to the 12th, in which Newton Wonder provided the material, the percentage germination was approximately the same and four other series of trials carried out during May and June yielded similar results. When continued in August and September the germination was very feeble indeed and later, in November, conidia which developed on the tissues of a breaking bud "forced" in the laboratory did not germinate although apparently normal.

These results led me to undertake a further series of trials in the following year, 1926, to investigate the factors limiting germination.

The Effect of the Host Plant on Germination of Conidia.

In a trial on April 24th, 1925, conidia from apple leaves were sown in two watch glasses containing tap water. A mildewed leaf was placed in one of these vessels and both preparations were kept in a damp atmosphere under a bell-jar. After three days a very small percentage had germinated in the preparation containing tap water alone; that to which the mildewed leaf had been added contained no germinating spores, presumably because tannin and products of decomposition had diffused from brown areas on the leaves into the water, and thus produced a medium inhibitory to germination. It was then thought that the sowing of conidia on a healthy leaf might influence germination. Accordingly, conidia were sown on a healthy leaf placed in a moist Petri dish and the necessary control was sown in a moistened watch glass, covered and placed in a damp chamber. The conidia on the leaf germinated and conidiophores

were produced six days later; no germination occurred in the moist control. Sometimes two or even three germ tubes were produced from conidia sown on healthy leaves whereas, in the event of germination occurring in a moistened watch glass or on a slide, never more than one germ tube has been observed. In other trials at temperatures of 0° C., 10° C., and 15° C. poor or no germination was constantly observed in the absence of healthy leaf tissue. Conidia of *P. leucotricha* sown on healthy, young oak leaves, set up in a similar way, germinated successfully, which seemed to indicate that an apple leaf exerts no peculiar influence. As was expected, conidiophores were not formed on oak foliage although an extensive growth of hyphae was evident, whereas in a control on apple leaves conidiophores were produced in the usual time. In another trial the expressed juice of healthy, green apple leaves was used as a germinative medium; no germination occurred therein or in a control of water alone but germ tubes were produced when sown in the normal manner on healthy apple leaves. Neither a watery extract of horse dung nor a two per cent. solution of cane sugar brought about germination. A healthy leaf apparently provides a most favourable substratum for germination although no adequate explanation suggests itself for this: possibly transpiration or the exchange of gases from the leaf might provide suitable conditions for the germination of the conidia of this mildew.

The Effect of Temperature on Germination of Conidia.

It was thought that temperature might directly affect the germination of conidia and thus be a factor controlling the seasonal appearance of the disease, Salmon's results with *Sphaerotheca Humuli* suggesting that the absence of spring frosts might check it somewhat.

Accordingly, preparations were set up in Petri dishes moistened with sufficient water to keep the leaves turgid. The conidia were gathered from fresh material and sown on healthy leaves lightly sprayed with tap water by means of an "atomiser." No germination had occurred after the Petri dish had been buried in ice for fifty-four hours. A leaf was removed after subjection to this temperature for twenty-four hours, and germination took place seven hours later at a temperature of 10° C. A leaf removed from the ice chamber after a fifty-four hour period showed in six hours at a temperature of 10° C. conidia with germ tubes which extended a distance equal to their length. In a control in which conidia were sown on slides kept moistened in a damp chamber, germination did not occur after thirty-one hours either in ice or in the laboratory at 10° C. One of the slides placed in the ice chamber was removed after twenty

hours to the laboratory temperature of 10° C., but no germination occurred.

After subjection to a temperature of 8° C. for twelve hours conidia sown on an apple leaf germinated upon removal from the cold chamber and conidial chains were developed six days later. Control conidia on leaves in the laboratory at 15° C. produced conidiophores at approximately the same time as those subjected to cooling. In other trials normal germination occurred on leaves at a room temperature of 10° C. twenty-four hours after sowing. In an incubator kept at a temperature of 20° C., vigorous germination occurred on leaves after twenty-four hours. The germ tubes were twice as long as those of conidia from an identical source sown at the same time in a temperature of 10° C. Another series of leaf preparations was subjected to temperatures of 15° C., 20° C., and 33° C. Careful examination of conidia on the leaves showed that germination was initiated at 15° C. after six hours and had not begun at 20° C. or 33° C. By the end of a period of twenty-one hours the production of germ tubes at 20° C. was in advance of those at 15° C., but was altogether absent at 33° C. in which the light brown colour which many conidia assumed showed that they had been killed. Moreover, well-defined areas of the leaves had been killed by the sudden change to excessive heat.

Temperatures from 0–10° C. do not tend to stimulate germination but rather to keep the conidia in a dormant condition; 10–15° C. is most favourable, 20° C. favours the growth of germ tubes, and 33° C. causes death of the conidia. These temperature relations apply to artificial conditions obtaining on excised leaves in a Petri dish and, although near to, do not perhaps, truly represent natural conditions for infection and growth of the fungus.

Moisture and Light Relations.

Neger (20) found that light caused acceleration of germ tube development in many of the Erysiphaceae. This factor has little or no influence on the germination of conidia of *P. leucotricha*, germ tubes being produced readily in the darkness of an incubator and at night. Moisture, however, is of some importance; surplus water on the leaf surface is unfavourable. Successful germination was obtained when the leaf to be inoculated was sprayed lightly with an "atomiser" at the time of sowing, comparable to a light fall of dew. Once germination had taken place, although the leaf surface was not further moistened, a vigorous growth of hyphae was induced followed by a copious development of conidiophores. On the other hand, production of mycelium and conidia did not occur on moist

portions of the leaf and germination was impeded by a very wet leaf surface. Moreover, a dry leaf surface favoured the rapid extension of hyphae and encouraged the production of conidial chains, but for this the host tissue had to be turgid and of high water content. Trials undertaken to discover whether conidia sown on a dry leaf would germinate showed normal germination to occur followed eventually by the development of conidiophores.

In nature a dry spell is not inhibitory to germination and to the dissemination of the disease. Although sufficient moisture is always supplied by night dews, even this seems unnecessary. It has been noted that during dry seasons mildew is more epidemic as, for example, during the season of 1921. Probably the season itself only indirectly influences the disease, whose incidence is directly controlled by the vigour of the host plant. Tender tissue of high water content is very susceptible to attack and whenever seasons or cultural practices bring about these conditions the disease is encouraged.

II. The Mechanism of Infection and Means of Dispersal.

The Penetration of the Cuticle and Formation of Haustoria.

Grant Smith (36) has described in some detail the mechanism of haustoria formation in *Erysiphe communis* on *Geranium maculatum*. The description he has given of cuticular penetration agrees closely with that observed by the writer in *P. leucotricha* with the exception that the haustorial sheath is often absent in this mildew. The sheath* as described by Smith precedes the advancing haustorium and, it is said, is composed of the decomposed distal portion of the cellulose protrusion which is formed in advance of the fine, penetrating process of the fungus. The decomposed cellulose which is formed completely round the haustorium is confined by the membrane of the host cell and the membrane eventually forms a U-shaped pocket in the epidermal cell. The cell membrane did not always remain intact, and then the haustoria were unprovided with sheaths, the haustorial membrane being in direct contact with the protoplasm of the host cell.

This description would serve also for *P. leucotricha*. Plate XVII, figs. 3–6, illustrate typical penetration of the epidermal cell. Connection with a parent hypha is difficult to obtain. At the point of contact with the host plant no special organ or thick-

* Harper, R. A., *Pringsh. Jahrb. wiss. Bot.* xxix (1896), 664, has given a different interpretation to this sheath. He considers it to be the disorganising nucleus of the host cell.

ening suggestive of an appressorium has been observed; the hypha is drawn out into a heel-like process (Pl. XVII, fig. 8), but the actual connection between parasite and host arises directly from the hypha and not from any outgrowth or protuberance of the hypha.

There are two hypotheses regarding the means by which penetration of the cuticular barrier is effected, but neither has been evolved from the study of infection processes peculiar to an obligate parasite. The first was postulated by de Bary (2) in 1886, infection of stems of broad beans by *Sclerotinia Libertiana* having led him to conclude that the cuticle was softened by a substance secreted by the fungus and that a toxic substance diffused through the cuticle, causing the death of the cell. Marshall Ward (40), in his study on *Botrytis*, found that parasitical attack on the cuticle was fostered by enzymatic action and that the fungus lived on the gelatinised walls. Yellow spots were caused by the deposition of an enzyme on the host at the tips of invading hyphae; owing to the difficulty in dealing with an obligate parasite such as *P. leucotricha*, any attempt to prove the existence of an enzyme involves great technical obstacles.

The second hypothesis was advanced by Blackman and Welsford (4) and Brown (5 and 6) as a result of their studies on *Botrytis cinerea*.

Blackman and Welsford showed that actual penetration was effected by pressure exerted on the underlying tissues, accompanied by the development of a fine peg-like growth from that part of the germ tube firmly pressed against the leaf surface. Prior to penetration of the cuticle no softening, swelling, or any other change was observed in the cuticle or in the underlying layers of the epidermal wall. Penetration could occur without the development of an appressorium but it was shown that attachment to the host, in penetration by mechanical force, was provided by a mucilaginous sheath investing the germ tube. As soon as the cuticular barrier had been forced, enzyme action could occur, as was made evident by the swelling of the subcuticular layers.

Results of preliminary observations on infection by germ tubes of *P. leucotricha* seemed somewhat similar to those of de Bary and Marshall Ward. When a conidium of *P. leucotricha* is placed on the surface of a leaf and germination occurs, a small area of the surface of the host tissue situated directly under and near to but not at the tip of the germ tube becomes light brown or yellow. This also occurs under other portions of an extended hypha. In these experiments whole, healthy apple leaves were used and the conidia were sown so as to ensure distribution on the midrib and larger veins as these portions particularly lend

themselves, through the absence of chlorophyll, to ready examination with an ordinary microscope. The discoloured area is not confined to one cell but spreads over adjoining cells not underlying the hypha, making it clear, therefore, that this discoloration cannot be due to haustorial penetration, a point which is confirmed by sections. The colour, moreover, is not typical of the browning within the epidermal cell which often follows the development of haustoria. Similar browning of well-defined areas of the leaf surface in contact with germ tubes from conidia of *P. leucotricha* sown on young oak leaves has also been observed: the colour of the affected portion is darker on this host but the area extends in the same way over adjoining cells. The infecting germ tubes were not immersed in water or in an "infection drop" at any time during these observations; they lay on a substratum visibly free from water.

Although hyphae of *P. leucotricha* conform closely to the leaf surface, they are not firmly attached until haustoria have been formed. Microscopical preparations have not shown hyphae adpressed against the cuticle of the host at the point of penetration, or attachment by a mucilaginous sheath. Some means of maintaining contact between hypha and cuticle during penetration must be shown to exist before the theory of penetration by mechanical force can be accepted to explain the penetration of *P. leucotricha*. If penetration is purely mechanical, a relatively great force must be exerted to penetrate the strongly cuticularised cuticle. Without means for maintaining a close contact between host and parasite during the exertion of the force, it is difficult to imagine mechanical penetration. Nordhausen (23) found that heavy dews so weakened the enzymes of the spores of *Botrytis* that penetration was impossible and that for enzymatic action to ensue the leaf surface must be dry. With *P. leucotricha*, whenever the leaf is kept covered by a film of water infection does not occur. When the cuticle is thick, a knob-like swelling of the penetrating organ occurs (Pl. XVII, figs. 7 and 8) somewhat similar to that observed by Grant Smith (*loc. cit.*) in *Erysiphe communis*. This enlargement of the passage through the cuticle occurs near the exterior and might be a pit-like cavity caused by enzymatic action. Also the slight swelling of the cuticle (Pl. XVII, figs. 3 and 4) which accompanies penetration might be due to enzymatic action. After its passage through the cuticle the penetrating hypha becomes thin and peg-like. To what extent either of the two hypotheses of penetration may explain the infection processes of *P. leucotricha* still remains to be demonstrated plainly.

After penetration of the epidermal cell has been effected and the young haustorium formed, the nucleus is introduced, pre-

sumably by way of the extremely narrow canal through the cuticle. Although its passage has not actually been observed, it must, as Smith has pointed out, be a remarkable process, for the tube has a diameter many times less than that of the nucleus. The mature haustorium is usually uninucleate but occasionally binucleate (Pl. XVII, fig. 7). Dark-coloured granules may be distinguished in a suitably stained haustorium nucleus. Although the attacked epidermal cell usually contains one haustorium, two or more have sometimes been observed. When the haustorium is fully mature it often occupies the greater part of the interior of the cell and, except where the invaded cells have turned brown, the host nuclei normally retain their function; the nuclei of the haustoria and of the host coexist in the infected cell without any apparent influence upon one another.

It has been noted that young leaves of high water content favour infection and that an absence of moisture on the leaf surface is not unfavourable to successful infection. In order to study the conditions in nature under which "secondary" infection occurred, observation was kept on a number of trees for the spread of the disease from affected to healthy parts. When dissemination occurred, it was by means of conidia from infected leaf or blossom clusters which developed from infected buds.

Dispersal of the Disease in Relation to "Secondary" Infection.

The mildew apparent at bud-break is derived from hibernating mycelia established there during a previous season, and is rarely, if ever, due to infection from outside sources. The presence of mildew in spring, then, is dependent entirely upon the existence of infected buds and the number and distribution of these buds determine the severity of attack. Detailed observations on a number of trees showed no "secondary" infection or infection of tissues (blossoms, leaves, etc.) other than that which developed with the tissues arising from an infected bud. Although "secondary" infection plays a part in the distribution of the fungus, the importance of this phase in the life-history as a means by which the disease might extend and become more and more widespread in the plantation has been over-emphasised for normal conditions. Close observation for the appearance of "secondary" infection was kept on fourteen apple trees among which were the varieties Ribston Pippin, Sturmer Pippin, Mr Gladstone, Baumann's Reinette, Lord Derby, Cox's Orange Pippin, and Bismarck. These trees, which were two years old on Paradise stocks, were selected from a commercial nursery as being badly mildewed during the summer. They were

transplanted at Cambridge in the autumn. On leaf-fall the infected "one-year-wood" was easily distinguishable by its white coating of mycelium, and this retained sufficient contrast through the winter to provide sharp differentiation from uninfected wood.

The evidence is entirely opposed to the possibility of the spread of the disease by "secondary" infection. The year 1924, in which the observations were made, was not exceptionally mildew-free and conditions alleged to be typical for the spread of the disease obtained. In 1925 and early 1926 observations made were in keeping with those of the former year. Many examinations in the orchard constantly revealed that, in general, infections arose from and were entirely restricted to those portions of the tree mildewed the previous season, *i.e.* upon portions where buds harboured the fungus through the winter months. What appeared remarkable was that buds which did not harbour the fungus, although situated between infected buds on an infected twig, opened and remained entirely free from mildew throughout the summer.

Severe attacks of mildew are encouraged by the presence of new leaves and young shoots formed later in the summer as a result of a check in growth from some cause. This check may be brought about by a severe mildew attack resulting in a "die-back" or, which is a frequent occurrence in certain districts, an attack on the shoots by the capsid *Plesiocoris rugicollis* which encourages the formation of an excessive number of side shoots, especially on the extremely mildew-susceptible variety Lane's Prince Albert. The later-formed shoots arising from buds which would otherwise remain dormant are usually infected by conidia from the original shoot, if, indeed, they do not themselves arise in an infected condition from infected buds. In consequence, there appears to be a fresh outbreak and spread of the disease which, actually, is only the provision at the original centres of infection of fresh material sufficiently tender to encourage the disease into renewed activity. It is not denied that fresh infections take place, but it seems that, except where abundant new growth is encouraged late in the season, the spread of the disease by "secondary" infection has been generally over-estimated. On under-nourished or otherwise ill-treated trees in which growth has been induced late in the year the spread of the disease is sometimes noticeable.

III. External Symptoms of Leaf Attack with Observations on Accompanying Physiological Phenomena.

When a young leaf is heavily infected it never attains its normal expansion or shape but tends to be slightly or decidedly

dwarfed and somewhat elongated. Manaresi (17) found apple leaves affected by *P. leucotricha* to be thicker than healthy leaves. I have encountered suspected hypertrophy which might be offered in explanation of this phenomenon.

As early as June affected leaves become brittle. Conidia are then less evident, due to the drying of the leaf tissue and to the destruction of spores through the very rapacious habit of Cecidomyid* larvae. Browning of affected leaves soons sets in, usually at the tips, the discoloured area spreading gradually until the entire leaf becomes brown, giving an infected shoot the appearance shown in the photograph (Pl. XVI, fig. 2). The browning effect on leaves is not uncommon in parasitism by Erysiphaceae, notably in *Uncinula necator*, but nowhere else, perhaps, is this phenomenon so noticeable as when leaves are attacked by *P. leucotricha*: browning, resulting in the rapid death of the tissues, is one of the most destructive phases of this disease.

The premature death of the leaves—brought about directly or indirectly by mildew attack—has occupied my attention during the course of this investigation. The key to the problem, it is plain, lies hidden in the haustoria. In 1923 Neger (21), in *Erysiphe Cichoraccarum* and *Sphaerotheca Humuli*, observed that leaves from certain host plants, when sown with conidia, assumed a spotted appearance over affected places. Numerous minute, reddish brown areas appeared, giving the impression that the leaves had been sprayed with corroding poison. The affected epidermal cells, on loss of turgidity, were observed to sink, appearing pit-like. Host plants not normally infected by the particular species or biological strain of the mildew under trial developed brown spots which were the result of the formation of masses of gum round the haustoria in the affected epidermal cells. Neger considered the spotting indicative of sub-infection.

Three causes of the severe browning and death of the leaves suggested themselves: (1) the adoption by the parasite of an endophytic habit; (2) the emission of a toxic substance by the fungus; and (3) the checking of respiration due to interference with gaseous exchange, and excessive transpiration through paralysis of stomata.

An abnormal endophytic habit, contracted in severe parasitism, might account for the rapid browning and death of affected leaves. It does not seem impossible to account for the adoption of an endophytic habit through an aggravated form of parasitism inasmuch as Salmon (33) has induced endophytic

* A species of *Mycodiplosis*, cf. Neger, F. W., Nat. Zeits. f. Land- und Forstwirts. XII (1915), 1.

attack by a mildew by wounding the host. In severe attack by *P. leucotricha*, mycelium was observed in the epidermis, palisade tissue and spongy parenchyma and sections also showed in these parts fungal organs strongly suggestive of haustoria. Preparations from natural and artificial infections showed mycelium within the inner tissues of the brown leaf, but no actual connection of hyphae to haustoria other than in the epidermal cells was found. The appearance of the host tissue suggested that the leaf, after becoming much weakened, had lost its power of resistance, and allowed easy access to the fungus. Klika (16) has recorded endophytic penetration by hyphae of *Erysiphe Polygoni*, *E. Cichoracearum*, *Uncinula Aceris*, *Trichocladia Astragali*, and *Sphaerotheca Humuli*, observed especially in older leaves in autumn. The abnormal endophytic habit of *P. leucotricha* might accelerate death, but the rôle played in this respect is not of great importance as it has been observed only in moribund or semi-moribund tissue. It seems probable therefore that endophytic penetration is the result and not the cause of severe parasitism of the leaves.

The emission of a toxic substance was next considered as a cause of ultimate death of the leaves. Sections through the junction of green and brown tissues revealed in the green tissue the formation of an apparently gummy substance which enclosed haustoria in the epidermal cells affected. Neger (*loc. cit.*) has called the entrapment thus brought about "encapsulation." The entrapment of the haustorium must arise from a reaction probably either toxic or enzymatic or both. The phenomenon has constantly been observed as a forerunner of browning. An early stage of "encapsulation" is illustrated in Pl. XVII, figs. 9 and 10. The nucleus of the haustorium becomes ill-defined, probably as a result of disorganisation following isolation of the haustorium from the host plant. Browning of palisade cells situated immediately below "encapsulated" haustoria often occurs; in the absence of the parasite it can only be assumed that a toxic substance has penetrated to these underlying cells. It is probable that the plant tissue, weakened by the continual withdrawal of food stores, succumbs to the toxin set up by "encapsulated" dead haustoria. The epidermal cells first lose their function; the toxin then spreads to the underlying tissues until, ultimately, all affected tissues die. Examinations showed a gradation in the number of entrapped haustoria according to the severity of browning of the leaf. In the dead leaf tissue the haustoria had succumbed, the cells had collapsed, and neighbouring invaded cells, if not themselves undergoing the same disorganising process, were rapidly killed either by the products of decomposition of adjoining dead cells or by a toxic substance

emitted by entrapped haustoria. In late stages of infection the attacked epidermal cells were filled with spherical, dark-coloured globules.

The checking of respiration due to interference with the gaseous exchange is probably a supplementary cause of browning. Stomata in leaves of the apple are entirely confined to the under surface, and when this is severely attacked, and dense conidial chains formed, the stomata are probably handicapped in the performance of their normal function. Transpiration would also be interfered with, but especially when guard-cells are parasitised and partially or totally paralysed. The dry, brittle nature of affected leaves may partly be due to excessive transpiration brought about by the sluggish action of the stomata.

IV. Results of Cross Inoculations of Different Varieties of Apples and Other Plants.

It was thought that so-called "biological species" might be present in *P. leucotricha* and that they might be limited to certain varieties of apples or to certain host plants. Experiments were conducted: (1) To discover to what extent "specialisation" existed in *P. leucotricha* occurring on apple, quince, and pear respectively. (2) To discover whether "strains" in mildew occurred on different apple varieties.

Conidia from the desired source were sown on leaves in a moistened Petri dish. In successful inoculations under suitable conditions conidial chains could be observed in six days. The following results were obtained from inoculations carried out on apple, pear and quince with conidia from each of these sources:

Host inoculated	Source of conidia	Date of inoculation	Date of prod. of conidiophores
1925:			
Quince	Lane's Prince Albert	May 30	June 5
,,	,,	,,	,,
1926:			
Quince	Cox's Orange Pippin	Apr. 15	Apr. 21
Cox's Orange Pippin	Quince	,,	,,
Pear	Cox's Orange Pippin	,,	,,
,,	Quince	,,	,,
Quince	,,	,,	,,
,,	Cox's Orange Pippin	Apr. 17	Apr. 24
Pear	Benn's Red	Mar. 7	Mar. 14
"Bridged" inoculations:			
Cox's Orange Pippin	Quince "bridged" by Cox's Orange Pippin	Apr. 30	May 6
,,	Cox's Orange Pippin "bridged" by Pear	,,	,,
,,	Quince "bridged" by Pear	,,	,,

From these results it is evident that conidia of *P. leucotricha* are capable of infecting each of the respective host plants mentioned, regardless of the source of conidia. Inoculations of pear leaves with conidia from the apple variety Lane's Prince Albert were unsuccessful later in the season (May 16th and June 6th, 1925), although, in a control, infection of healthy leaves of the same apple variety was vigorous. The rapid thickening of the cuticle of the pear leaf compared with that of the apple may explain this. No specialisation of parasitism is apparent. The infections resulting from the cross inoculations made did not suggest "sub-infection"; they were vigorous and in time became extensive. The infection power of conidia from such infections is not decreased as observed by the successful "bridged" inoculations above recorded.

It is interesting to note that under natural conditions in this country the pear is seldom attacked by *P. leucotricha*. The writer has in mind a large plantation of apples of various varieties interplanted with pears, which have constantly resisted the disease, though the apples were severely mildewed each season. Fisher (10), however, reported an outbreak of the disease on pears in 1921 in central Washington. He did not find the infections general but confined to "watersprouts" and "terminals." The mildew had been epidemic on apples interplanted since 1914. The morphological characters of the fungus on pears did not differ from those of the mildew on apple, but the general occurrence of perithecia on the fruit instead of on the twigs was noteworthy.

Although it was thought unlikely that "biological species" were present on the various apple varieties the following inoculations were carried out to prove it:

Host inoculated	Source of conidia	Date of inoculation	Date of infection
1925:			
Early Victoria	Early Victoria	July 15	July 21
,,	Mr Gladstone	,,	July 22
Mr Gladstone	Early Victoria	,,	Aug. 4
Cox's Orange Pippin	Cox's Orange Pippin	,,	,,
Worcester Pearmain	,,	,,	July 25
Cox's Orange Pippin	Mr Gladstone	,,	,,
1926:			
Beauty of Bath	Benn's Red	Apr. 7	Apr. 15
White Transparent	,,	,,	,,
Cox's Orange Pippin	Grosvenor	,,	Apr. 19
Worcester Pearmain	Benn's Red	,,	Apr. 15
Cox's Orange Pippin	Ribston Pippin	,,	,,
,,	Newton Wonder	,,	,,
,,	Early Victoria	,,	Apr. 19
,,	Sturmer Pippin	,,	Apr. 15
,,	Lord Derby	,,	,,
,,	Bismarck	,,	Apr. 19
,,	Worcester Pearmain	,,	,,

Inoculations during the latter part of July, 1925, and later were unsuccessful; the leaves had become more mature and presumably more resistant. It seemed safe from the number of positive infections recorded above that there existed in *P. leucotricha* no "races" specialised to certain varieties of apples.

V. Susceptible and Resistant Apple Varieties.

Apple varieties may be arranged in three categories according to susceptibility to mildew*. In the first category, those very susceptible, may be included Cox's Orange Pippin, Bismarck, Lane's Prince Albert, Allington Pippin, Stirling Castle, Newton Wonder, Early Julian and Annie Elizabeth. Among those more resistant are James Grieve, Beauty of Bath, Lord Grosvenor, Lord Derby, Mr Gladstone, Grenadier, Early Victoria, Jolly Miller, Charles Ross and Bramley's Seedling. In the third class, those highly resistant, Worcester Pearmain and Norfolk Beauty have been included. Other varieties could be added to the above categories, but reference has been made here only to those more commonly grown for commerce. Generally speaking, so-called Russian varieties of apples are more susceptible to attack and soft apple varieties are more susceptible than hard varieties. But above all, the soil, and general cultural practices, both of which determine the vigour of the tree, are largely responsible for epidemics and outbreaks of the disease.

Notes on Control Measures.

"Secondary" infection does not play a part of great practical importance in spreading the disease during the summer months, and therefore spraying solely to check the spread of the conidial stage of the disease cannot be recommended as an economical proceeding. Furthermore, no satisfactory spray fluid has yet been found which successfully controls the conidial stage of the fungus although Salmon (34) and others have recently used ammonium polysulphide with some success for the control of the conidial stage of another mildew. The writer carried out a number of preliminary trials with lime sulphur (1–60) in attempts to prevent early establishment of mycelium on young shoots which emerge from infected buds, or to kill such hyphae as had already become established thereon, and thus destroy the fungus at a vulnerable stage in its life history and prevent infection of axillary buds. A number of twigs of Lane's Prince Albert at Cambridge were individually sprayed at two fortnightly intervals during emergence, but in no case was the

* Acknowledgment is here made to Mr N. H. Grubb for corroboration and the inclusion of four varieties not personally observed by the writer.

mildew destroyed. In fact, a number of the treated twigs eventually bore dense masses of perithecia. At Evesham eighty trees of the apple variety White Transparent were similarly treated with a power mechanical sprayer using the same solution with the addition of arsenate of lead, but no obvious reduction in mildew was effected. The conidial stage on the leaves was not satisfactorily repressed or hyphae on the twigs destroyed.

Summary.

1. *Podosphaera leucotricha* perennates by means of hyphae and haustoria within dormant apple buds. Young axillary buds are invaded soon after their formation when the buds are inadequately protected by bud scales. Terminal and axillary buds on "one-year-wood" and blossom buds on spurs are most frequently invaded.

2. Only forty to fifty per cent. of mildewed twigs bear buds that open in an infected condition.

3. The perithecia are characterised by a depression: the apical appendages taper to a point and are non-septate.

4. The formation of perithecia is favoured by severe hyphal infection of the host in a young stage.

5. Water has a slight germinative influence on conidia. A dry healthy leaf in a turgid condition provides a substratum favourable to germination and rapid extension of infection.

6. Between 10 and 15° C. germination requires six hours. Freezing does not stimulate germination.

7. The penetration of the cuticular barrier appears to be by chemical rather than by mechanical action.

8. Two or more haustoria may be present in an epidermal cell. They are usually uninucleate.

9. "Secondary" infection has been over-emphasised; no general infection arises other than that which develops from infected buds.

10. Occasionally fresh foliage induced by "die-back" brought about by severe mildew attack or by the capsid *Plesiocoris rugicollis* extends infection.

11. A heavily infected young leaf never attains its normal development but tends to be dwarfed and somewhat elongated.

12. Browning of the leaves appears to be due principally to the death of tissues caused by toxins set up by encapsulated haustoria.

13. No "specialised races" were encountered. Conidia produced on different varieties of apple and on quince and pear are capable of cross infection.

14. Apple varieties vary in susceptibility.

15. The prevention of bud infection by spraying has not proved successful.

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EXPLANATION OF PLATES.

Plate XVI.

Fig. 1. A young shoot of Lane's Prince Albert severely attacked by *Podosphaera leucotricha*. ×⅔.
Fig. 2. Ditto, showing curling and dying of leaves. ×⅔.
Fig. 3. Blossom: infected (left) and healthy (right). ×⅔.
Fig. 4. Appearance after "setting" of fruit. ×⅔.

Plate XVII.

Fig. 1. Median L.S. through dormant leaf bud of infected terminal shoot of Cox's Orange Pippin, after removal of bud scales. ×25.
Fig. 2. Perithecia of *Podosphaera leucotricha* showing concave depressions and apical appendages.
Figs. 3–8. Haustorium formation of *P. leucotricha*. Fig. 3. Thickening of cuticle and depression of cell-membrane with outgrowth from hypha in cuticle. ×875. Fig. 4. Depression more pronounced. ×875. Fig. 7. Binucleate haustorium. ×1150.
Fig. 9. Encapsulated haustorium in enlarged epidermal cell. ×215.
Fig. 10. Ditto, showing disorganising nucleus of haustorium and barrier. ×875.

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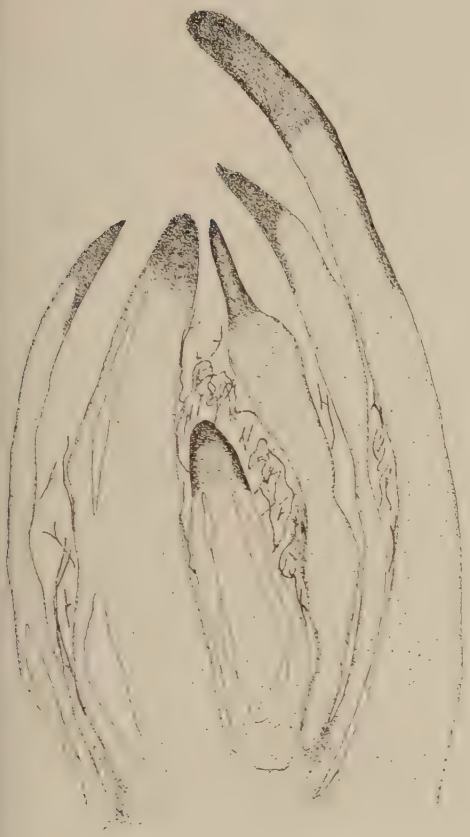
Podosphaera leucotricha



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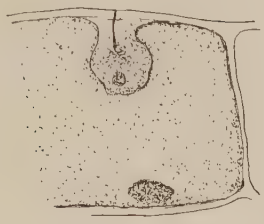

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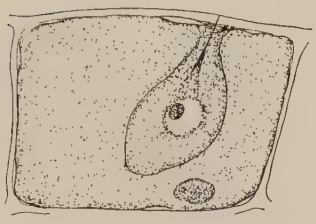

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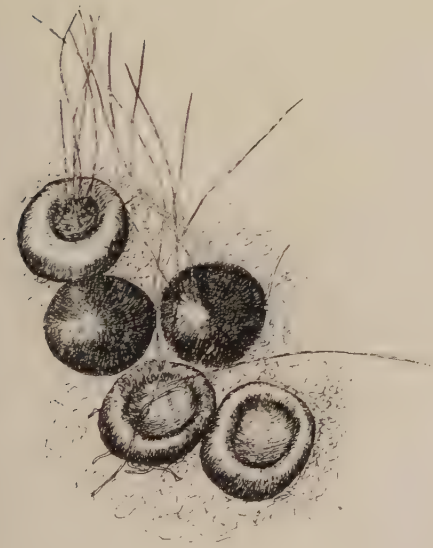

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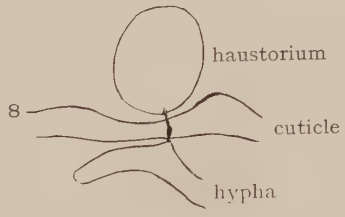

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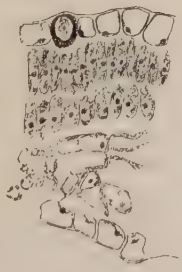

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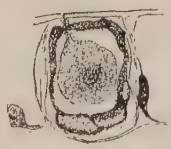

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Podosphaera leucotricha

APPENDIX TO "BRITISH BASIDIOMYCETAE."

ADDITIONS AND CORRECTIONS.

By Carleton Rea, B.C.L., M.A., Hon. Member British Mycological Society, etc.

FIVE years have now elapsed since the publication of my book on the *British Basidiomycetae*. During this period numerous additions have been made to the species enumerated in that work and several corrections are necessary after further investigation. It is somewhat curious that two of these additions should be due to American investigators, namely the record of *Leucogaster floccosus* Hesse by S. M. Zeller and C. W. Dodge, based on the specimen in Rabenhorst's Fungi Europeae exsiccati, no. 38, in the Farlow Herbarium at Harvard University; and the addition of *Peniophora miniata* (Berk.) Burt to Prof. E. A. Burt from Berkeley's British Fungi exsiccati, no. 251. The other additions and corrections are mainly due to the kindness of many friends, including the late W. B. Allen and his widow Mrs M. Joyce Allen, the Rev. J. Harvey Bloom, Miss C. A. Cooper, E. J. H. Corner, E. Metcalfe Day, Rev. E. A. Elliot, Miss J. C. Eyre, C. H. Grinling, St John Marriott, A. A. Pearson, J. Ramsbottom, Violet Rea, E. W. Swanton, and Miss E. M. Wakefield. To all of these I accord my heartiest thanks and more especially to E. J. H. Corner and A. A. Pearson.

In the following list I have indicated by an asterisk the position the species should have in the body of the work, and I have also emended the key to the divisions and genera of British Basidiomycetae.

Emend key to the divisions and genera of British Basidiomycetae as follows:

p. 4. HYMENOGASTRACEAE.

B. Peridium with external mycelial strands. Gleba cavities at first hollow. Spores elliptical, *smooth*	*Rhizopogon.*
Gleba cavities at first filled with a gelatinous mass. Spores hyaline or slightly coloured, *embedded in a gelatinous sheath*, globose or elliptical, *with various surface markings.*	*Leucogaster.*

p. 13. Add to *Hypochnus*: No cystidia — *Hypochnus.*
Like *Hypochnus* but with cystidia — *Tomentellina.*

p. 14. After *Epithele* add — *Epithele.*

Receptacle resupinate, effused, membranaceous, crustaceous or floccose. Hymenium smooth, farinose or pubescent. Spores white. Sterile mycelial hyphae (paraphyses) dichotomously branched, forming a rounded head beneath the basidia — *Asterostromella*

p. 16. After *Pistillaria* add — *Pistillaria.*

Receptacle minute, erect or pendant, somewhat firm, *pin-shaped*, stem cylindrical, smooth or villose, *enlarged at the apex into a convex disc covered by the hymenium*, which is sometimes ciliate at the margin. Spores white. Epiphytic or growing on dead leaves — *Pistillina.*

After **Auriculariales** add

1. Saprophytes with probasidia — SEPTOBASIDIINEAE.
2. Parasites with or without probasidia
3. Saprophytes without probasidia

SEPTOBASIDIINEAE.

Same characters as suborder — SEPTOBASIDIACEAE.

SEPTOBASIDIACEAE.

Receptable effused, floccose, or gelatinous, probasidium lateral — *Saccoblastia.*

p. 19. After *Tulasnella* add — *Tulasnella.*

Like *Tulasnella* but the hymenium provided with gloeocystidia — *Tulasnella* (sub-genus *Gloeotulasnella*).

Leucogaster (Hesse) Zeller & Dodge*.

(λευκός, white; γαστήρ, belly.)

Peridium globose, or irregular, fleshy or waxy; fibrils sometimes present, leading to rhizomorphs; thin, fragile, sometimes rupturing at maturity, sterile base absent. Gleba cells frequently polyhedral, *usually filled with spores embedded in a gelatinous mass*; septa homogeneous, with or without a distinct trama, *often gelatinizing at maturity*. Basidia subglobose to ovoid and subcylindric, mostly with 4- rarely 3- or 5-sterigmata. Spores

* *Leucogaster* and *Leucophlebs* in North America by S. M. Zeller and C. W. Dodge, Ann. Missouri Bot. Gard. XI, 389, 402.

hyaline or slightly coloured, with various surface markings, *embedded in a gelatinous spherical mass.* Hypogaeous or emergent.

27*. **L. floccosus** Hesse. Hesse, Bot. Centralbl. XL, t. 1, 2, figs. 1–9. *Floccus*, a flock of wool.

Pe. 2–4 cm., *light yellow*, bay to auburn in alcohol, irregular; fibrils *black or nearly so*, loose, round; with thick, flocculent, concolorous patches; epidermis 120–150 μ thick, composed of small hyphae, the outer coloured to a depth of 10 μ, the inner gelatinizing. Gleba *slightly darker*, waxy in preserved specimens; septa hyaline, 100–150 μ, composed of large, closely woven hyphae. Spores echinulate, globose, 4 μ in diam., with gelatinous sheath 7–10 μ in diam.; basidia 7 × 12 μ, with 2–3-sterigmata. Underground. Birch and oak woods. Aug.—Sept. Rare. Batheaston, C. E. Broome in Rabenh. Fung. Eur., 38, Farlow Herb. at Harvard Univ. as *Hymenogaster citrinus* Vitt.

56*. **Geaster Schmidelii** Vitt. non Massee. (= *Geaster nanus* Pers. sec Hollós.) Hollós, Die Gasteromy. Ungarns, t. IX, figs. 7–11, as *Geaster nanus* Pers.

C. C. Schmidel, author of *Icones plantarum, etc.*

Exoperidium 1–3 cm., *whitish*, globose, splitting up into 5–8, unequal, acute lobes, divided up to about the middle, revolute, *brown inside* and becoming transversely cracked; endoperidium 4–10 mm., *brownish, or lead colour*, oval, or oblong, *shortly stipitate or subsessile.* Peristome prominent, long, conical, deeply sulcate, apex fimbriate. Stem ·5–2 × 2–4 mm., *pale yellowish*, cylindrical or compressed. Spores dark umber, verrucose, globose, 5–6 μ. Columella *paler*, oblong, half as high as the endoperidium or slightly higher. Capillitium brown, cylindrical, often rough and flexuose, 3–6·5 μ in diam. Sandy places and coniferous woods. Oct.—Nov. Rare. (*v.v.*)

59*. **Geaster minimus** Schwein. (= *Geaster marginatus* Vitt. sec. Hollós.) Lloyd, The Geastrae, figs. 50–52.

Minimus, smallest.

Exoperidium 1–2·5 cm., *white or ochraceous*, globose, splitting up into 5–9, unequal, acute lobes, divided to the middle, expanded, then recurved, *ochraceous* inside and slightly fleshy, flesh soon cracking and often peeling off; endoperidium 8–10 mm. in diam., 9–11 mm. high, *white or pale brown, often becoming blackish blue with age, oval*, pedicillate, *minutely granular*, then becoming smooth. Peristome conic, ciliate fimbriate, seated on a plane, circular disc. Stem 2–3 × 3–5 mm., *white*, cylindrical or compressed, *enlarged at the apex into an apophysis-like base to the endoperidium.* Spores fuscous, minutely warted, globose,

3·5–4·5 μ. Columella slender, nearly obsolete. Capillitium hyaline or yellowish, 3–4 μ in diam. Sandy pastures and amongst needles in coniferous woods. Sept.—Oct. Uncommon. (*v.v.*)

92*. **Pluteus Bullii** Berk.

This was dealt with as a variety of *Pluteus cervinus* (Schaeff.) Fr. in my *British Basidiomycetae* but I now consider it to be a distinct species. The cystidia *have no hooks at the summit*, are flask-shaped, 60–70 × 15–20 μ, apex 4–12 in diam., the spores are slightly smaller, 6–7 × 4–5 μ, and the whole facies of the fungus is really very different.

110*. **Pluteus luteovirens** Rea.

Luteus, yellow; *virens*, becoming green.

P. 2–4 cm., *deep honey-yellow tinged with green*, submembranaceous, convex, then expanded, *disc papillate and rugosely veined or wrinkled, striate from the disc to the margin*. St. 3·5–6 cm. × 2–5 mm., *white, shining*, equal or slightly attenuated upwards, *striate*, smooth. Gills *white, then flesh colour*, free, ventricose, 4–5 mm. wide. Flesh *white, yellow* at the thick disc and under the pellicle of the pileus, very thin at the margin. Spores pink in the mass, subhyaline under the microscope, globose or subglobose, 5–6 × 5 μ, multiguttulate. Cystidia abundant both on gill edge and surface, elongate-bottle-shaped, 35–50 × 14–17 μ, apex 5–7 μ in diam. Taste and smell none. Amongst moss on a stump of *Tilia cordata*. Aug. Rare. (*v.v.*)

128*. **Lepiota Pauletii** Fr. (= *Lepiota aspera* (Pers.) Quél. var. *Pauletii* (Fr.) Quél.) Barla, Champ. Alp. Marit. t. 15, figs. 12–15.

J. J. Paulet, author of *Traité des Champignons*.

P. 3–10 cm., *whitish tawny, covered with thin, pointed, darker coloured scales or warts*, convex, then plane. St. 4–6 × 1–3 cm., *whitish, or tinged with tawny*, attenuated upwards, base bulbous. Ring *white, or tinged with tawny*, membranaceous, *fugacious*. Gills *white*, free, crowded. Flesh *white, becoming yellowish*, thick at the disc. Spores white, oblong-elliptic, 6–8 × 3 μ. Smell strong, taste pleasant. Woods. May—Oct. Rare. (*v.v.*)

140*. **Lepiota echinella** Quél. & Bern. Trans. Brit. Myc. Soc. xi, t. 6.

ἐχῖνος, a hedgehog.

P. 1·5–2·5 cm., *bay, becoming split into areolate, thin, hairy, pyramidal, brown squamules, darker at the apex*, campanulate, then convex, umbonate. St. 3–4 cm. × 2–4 mm., *rose or amethyst colour, sprinkled with blackish brown scales near the base*, equal. Ring arachnoid, silky, fugacious. Gills *whitish cream* colour, sometimes becoming stained with red, free, crowded,

2–3 mm. wide. Flesh *white, reddish in the stem,* thin. Spores white, pruniform, 4–7 × 2·5–3·5 μ. Smell of radish. Amongst dead leaves. Sept.—Oct. Not uncommon. (*v.v.*)

193. **Psaliota sylvicola** (Vitt.) Fr.

Spores brownish purple, broadly elliptical, 6–6·5 × 4–4·5 μ, with a large central gutta and oblique apical germ-pore.

207. **Anellaria fimiputris** (Bull.) Karst.

Spores purple-black, oblong-elliptical, 14–17 × 8–9 μ. Cystidia cylindrical or fusiform, often flexuose, 45–55 × 8–15 μ, apex 3–7 μ in diam.

261. **Armillaria mucida** (Schrad.) Fr.

Patouillard and Ricken state that there are no cystidia in this species, but there are abundant, hyaline cystidia, fusiform or cylindrical, 90–140(–180) × 15–25–30(–45) μ.

352*. **Cortinarius (Phlegmacium) intermedius** Rea.
Intermedius, intermediate.

P. 5–8 cm., *whitish, then clay colour, disc becoming ochraceous with age,* fleshy, compact, convex, then flattened, viscid, with a few innate darker fibrils; margin *white,* incurved, exceeding the gills. St. 5–6 × 1–1·5 cm., *white,* equal, base marginately bulbous, adpressedly fibrillose. Cortina *white,* fibrillose, fugacious. Gills *white, then clay colour,* emarginate, crowded, thin; edge finally paler, minutely serrulate. Flesh *white,* with a horn-coloured line at the base of the gills, becoming tinged with blue at the apex of the stem on section, compact, thin at the margin of the pileus. Spores ferruginous, verrucose, oblong or broadly elliptical, rounded at both ends, 9–10 × 5–6 μ. Basidia 25–30 × 8–9 μ, with 4-sterigmata. Smell strong, of starch. Taste mild. Woods, under oaks and nuts. Sept. Uncommon (*v.v.*)

393*. **Cortinarius (Myxacium) epipolius** Fr. Fr. Icon. t. 150, fig. 3. ἐπιπόλιος growing hoary.

P. 4–8 cm., *bluish grey tinged with yellow,* fleshy at the disc, thin elsewhere and submembranaceous, slightly viscid, convex, then plane, gibbous, glabrous, *silky-shining with an innate hoariness.* St. 7–8 × 1 cm., *whitish, becoming violet,* viscid, base clavately bulbous, elastic. Cortina fugacious. Gills *cinnamon,* decurrent, 6–8 mm. broad, broadest behind, subdistant. Flesh whitish, fuscous under the cuticle of the pileus, spongy in the stem. Spores ferruginous, subglobose, 8–9 × 6–7 μ, contents granular. Woods. Sept.—Oct. Rare. (*v.v.*)

441*. **Cortinarius (Dermocybe) Queletii** Bataille. Boud. Icon. t. 115, as *Cortinarius orellanus* Fr.
Lucien Quélet, the eminent French mycologist.

P. 2–4 cm., *tawny red, or brick-red*, fleshy, campanulate, then expanded and slightly depressed, covered with adpressed fibrils; margin slightly lobed. St. 3–8 cm. × 4–7 mm., *yellowish, tinged with red from the more or less crowded, red, fibrillose squamules*, base slightly thickened. Gills *lemon-yellow, then rust colour*, adnate, 4–6 mm. broad, subdistant. Flesh *pale, lemon-yellow in the stem*, thin at the margin. Spores ferruginous, oblong-oval, very minutely verrucose, 10–12 × 5–6 μ. Deciduous woods and charcoal heaps. Sept.—Oct. Uncommon. (*v.v.*)

541*. **Inocybe pseudofastigiata** Rea. (= *Inocybe fastigiata* Schaeff. sec. Rick.)

ψευδής, false; *fastigiata*, the species *I. fastigiata*.

P. 3–9 cm., *yellowish brown, or straw colour*, slightly fleshy, conico-campanulate, then expanded *with a prominent umbo*, longitudinally fibrillose and cracked; margin often irregularly split or torn, cortina pale, soon evanescent. St. 4–10 cm. × 4–15 mm., *pale, or brownish*, equal, or slightly attenuated upwards, often irregular or curved, fibrillose or subfloccose, apex obsoletely mealy. Gills *olive-yellow, then olive-brown*, sinuato-free, ventricose, somewhat crowded; edge often white floccose. Flesh pale, thin. Spores ferruginous, elliptical, often depressed on one side, with an oblique basal apiculus, 10–12 × 6–8 μ. Cystidia only on gill edge, cylindrical or clavate, more rarely ventricose or compressed near the apex, 40–55 × 8–17 μ ("50–60 × 15–20 μ" sec. Rick.); apex 6–10 μ in diam., obtuse. Coniferous and frondose woods. July—Oct. Not uncommon. (*v.v.*). *Inocybe fastigiata* (Schaeff.) Fr. has *no cystidia*, and the quotation from Ricken respecting the cystidia should be deleted from the description of this species on page 207 of *British Basidiomycetae*.

559. **Inocybe lacera** Fr.

Spores brown, oblong, obtuse, 12–16 × 5–6 μ. Cystidia fusiform, ventricose, 60–80 × 14–20 μ, numerous, apex brownish, muriculate, 6–9 μ in diam.

570. **Inocybe relicina** Fr. *Relicina*, curled backwards.

P. 2·5–4 cm., *fuliginous, or reddish brown*, fleshy, thin, conical, then expanded, obtuse, *everywhere scaly-squarrose with fasciculate down*; margin sometimes split or lobed. St. 4–7 cm. × 5–8 mm., *fuliginous, or reddish brown*, equal, fibrillose, *floccoso-scaly*, apex white-mealy. Gills *pale, then olivaceous and often finally ferruginous*, adnexed, crowded, edge white. Flesh of stem *reddish*. Spores ferruginous in the mass, pip-shaped, 10–12 × 6–7 μ. Cystidia cylindrical, ventricose, 60–80 × 13–17 μ. Smell and taste none. Damp pine woods amongst *Sphagnum*, and in bogs. July—Oct. Uncommon. (*v.v.*)

601*. **Astrosporina umbrina** (Bres.) Rea. (= *Inocybe umbrina* Bres.) Bres. Fung. Trid. t. 55, as *Inocybe umbrina* Bres.
Umbrina, umber-coloured.

P. 2–3·5 cm., *chestnut-brown*, fleshy, campanulato-convex, then expanded and umbonate, *somewhat viscid*, fibrillosely villose, then becoming very rimose, disc sometimes verruculose, at first covered with a very distinct *greyish fuscous* veil. St. 4–6 cm. × 3–5 mm., *subconcolorous*, subbulbose or subturbinately bulbose, base pilose, apex white-mealy. Gills *lurid citron-yellow, then rufescent-cinnamon*, edge *darker* (sometimes paler sec. Rick.), attenuated behind, or sinuato-adnate, crowded. Flesh *lurid*. Spores yellowish under the microscope, substellate, 7–8 × 5–6 μ. Cystidia fusiform, ventricose, 60–70 × 14–18 μ, somewhat fuscous and muriculate at the apex. Smell and taste none. Woods. July—Nov. Not uncommon. (*v.v.*)

632*. **Tricholoma guttatum** (Schaeff.) Rea. (non *Tricholoma guttatum* (Schaeff.) Fr., nec Quél.). Schaeff. Icon. t. 240. Cke. Illus. no. 76, t. 59. *Guttatum*, spotted.

P. 4–7 cm., *pale yellowish, becoming rosy towards the margin, covered with minute, brownish squamules, especially at the disc*, fleshy, convex, then flattened; margin involute, *often irregular and lobed*. St. 4–6 cm. × 8–12 mm., *white*, equal, attenuated at the base, smooth. Gills *grey, then tinged with rose*, emarginate, ventricose, 5–10 mm. broad, somewhat veined, distant; *edge uneven, undulate*. Flesh *white, becoming tinged with red when cut*, firm. Spores white, broadly elliptical, often depressed on one side, 5–6 × 4 μ, with a large central gutta. Smell and taste none. Amongst dead leaves under oaks in woods. Oct. Rare. (*v.v.*)

634*. **T. impolitum** (Lasch) Fr. *Impolitum*, unpolished.

P. 6–10 cm., *ochraceous, variegated with bistre or brownish black*, fleshy, convex, obtuse, *then subdepressed*, floccosely fibrillose, *becoming broken up into squamules*, disc subgranular; margin *white*, involute, *villose*, becoming smooth. St. 6–7 × 1·5–2 cm., *white*, equal, firm, fibrillose, *apex floccosely squamulose*. Gills *whitish*, emarginate, crowded, 6–8 mm. broad. Flesh *white*, compact. Spores white, broadly elliptical, with a basal apiculus, 5–6 × 4 μ, with a large central gutta. Smell none. Taste somewhat acrid, then peppery. Deciduous woods on calcareous soils, often growing in rings. Sept.—Nov. Uncommon. (*v.v.*)

670*. **Tricholoma sulphurescens** Bres. (= *Tricholoma resplendens* Fr. sec. Quél.)
Sulphurescens, becoming sulphur yellow.

P. 2·5–8 cm., *white, becoming yellowish with age and somewhat fuscous especially at the margin* ("*pale wash-leather colour, becoming whitish with subochraceous spots*" Bres.) fleshy, convex, then flattened, obtuse, *floccose* ("silky, then glabrous, dry" Bres.); margin *thin*, exceeding the gills ("sulcate with age" Bres.). St. 2–8 × 1–2 cm., *white, becoming sulphur-yellow, especially at the base on handling*, equal, base somewhat incrassated or rooting, apex *white-mealy, punctate with tawny, fuscous squamules* towards the base. Gills *white, becoming sulphur-yellow when bruised, and finally pallid*, sinuato-adnexed, rounded behind and almost free, *very narrow*, 2 mm. broad, *densely crowded*, often furcate at the base and sometimes higher up, edge acute. Flesh *white, becoming sulphur-yellow when broken*, compact, thick at the disc, very thin at the margin. Smell none ("foetid, like *Tricholoma sulphureum*" Bres., "fruity" Quél.). Taste somewhat bitter ("mild then slightly peppery" Bres.). Spores white, broadly elliptical or subglobose, bluntly apiculate, 5–8 × 3·5–5 μ ("5–6 × 4·5–5 μ" Bres.), punctate; basidia clavate, 20–28 × 5–6 μ ("30–35 × 8–9 μ Bres.), with 4-short-sterigmata. Cystidia none. Amongst beech leaves, under beeches and conifers. Oct. Rare. (*v.v.*) A very distinct species from *Tricholoma resplendens* Fr. in the description of which (no. 616) the statement "becoming yellowish externally and internally" should be deleted.

704*. **Tricholoma turritum** Fr. *Turritum*, turreted.

P. 5–14 cm., *fuliginous purple when moist, becoming grey when dry*, fleshy, *conico-campanulate, then expanded, acutely umbonate*, smooth; margin inflexed and finally somewhat split. St. 7–13 cm. × 8–20 mm., *white, becoming fuscous with the fibrils*, subequal, *fragile, base thickened* and white villose. Gills *white*, adnexed, *separating*, ascending, ventricose, crowded, distinct; *edge often delicately serrulate*. Flesh *watery, becoming white*, fragile, soft. Spores white, elliptical, 7–8 × 4–5 μ, with a large gutta, punctate. Damp places and on leaf mould in woods. Sept.—Oct. Uncommon. (*v.v.*)

748. **Entoloma majale** Fr.

I agree with Konrad in transferring this species to *Nolanea* and will deal with it as no. 1288* *Nolanea majalis* (Fr.) Konrad.

769*. **Hebeloma anthracophilum** R. Maire. Gill. Champ. Fr. t. 364, as *Flammula carbonaria*.

ἄνθραξ, charcoal; φίλος, loving.

P. 4–5(–7) cm., *fulvous, disc becoming fuscous*, campanulate or hemispherical, then expanded, more or less umbonate, glabrous, viscid, *pruinose with innate grey fibrils*; margin at first involute, white-tomentose, then expanded and floccose.

St. 5–8 × ·5(–1) cm., *white*, straight, cylindrical, silky with white fibrils and rough with concolorous squamules. Cortina none. Gills *whitish, then clay colour, at length ferruginous fuscous*, sinuato-adnate, or uncinate, ventricose, crowded; edge *whitish*, hardly denticulate. Flesh *whitish, firm, elastic*. Spores ferruginous fuscous in mass, pruniform, 10–11 × 6 μ, verruculose. Basidia cylindric-clavate, with 4- rarely 2-sterigmata. Cystidia none. Edge of gills with a few hairs, little differentiated. No smell of radish. Taste *instantaneously very bitter*. Charcoal heaps. Sept.—Nov. Not uncommon. (*v.v.*)

790*. **Hypholoma radicosum** Lange. (= *Hypholoma epixanthum* Rick. sec. Lange, *Flammula inopus* Rea, Brit. Basid. no. 998.) Cke. Illus. no. 484, t. 446, as *Flammula inopus* Fr. *Radicosum*, having a root.

P. 3–9 cm., *honey-tan, or reddish tan, paler round the margin from the white, silky veil*, fleshy, convex, then expanded, obtusely umbonate, or subgibbous, *at first covered by the white silky veil*, then becoming smooth. St. 7–25 cm. × 4–10 mm., *white above, brick colour below*, equal, or slightly enlarged before continuing *into the long, tapering, rooting base*, tough, flexuose, *apex mealy and white fibrillose, fibrillosely scaly below with subferruginous, subimbricate or transversely zone-like scales*. Gills *pale yellowish, or pallid, sometimes green, then becoming purplish*, adnate, emarginate, 6–7 mm. broad, thin, crowded; edge *white*, floccose. Flesh *yellowish, ferruginous in the stem*, thin at the margin. Spores purple, broadly elliptical, 6·5–8 × 4–5 μ, 1-guttulate. Cystidia bottle-shaped, 35–40 × 7–11 μ, apex 2–4 μ in diam. Smell very strong. Taste very bitter. Solitary, or caespitose. Coniferous, rarely frondose stumps. May—Dec. Not uncommon. (*v.v.*)

802. **Hypholoma catarium** Fr. *Catarium*, belonging to a cat.

P. 1·5–2·5 cm., *deep honey-yellow, becoming date-brown with age*, fleshy membranaceous, hemispherical, then expanded, *smooth*, hygrophanous; margin appendiculate with the white veil, striate, incurved, exceeding the gills. St. 1–2·5 cm., *whitish, rather* shining, somewhat silky, *firm, base incrassated* and white floccose, apex striate, *pruinose*. Gills *white, then fuscous*, adnate, narrow, rather crowded. Flesh *concolorous, becoming whitish*, thin. Spores fuscous purple, elliptic-oblong, 5–6 × 3–3·5 μ, multiguttulate. Gregarious or subcaespitose. Amongst grass in parks and roadsides, and on sawdust heaps. Sept.—Oct. Not uncommon. (*v.v.*)

843*. **Clitocybe pseudoconglobata** Rea.
ψευδής, false; *conglobata*, the species *Clitocybe conglobata*.

This species has exactly the same macroscopic characters as *Clitocybe conglobata* (Vitt.) Bres., including the white pruinose, involute margin, but differs in the white, *oblong* spores, with an oblique apiculus, 9–11 × 3·5–4 μ. Apple pulp refuse. Dec.—Jan. Uncommon. (*v.v.*)

871*. **Clitocybe fritilliformis** (Lasch) Fr.
Fritillus, a dice-box; *forma*, shape.

P. 3–5 cm., *dark brownish olive, greyish olive, or pallid grey, becoming fuscous when dry*, fleshy membranaceous, convex, umbilicate, then infundibuliform, *very firm*, glabrous, often rugulose; margin smooth, translucidly striate, flexuose, incurved, often sublobate. St. 3–7 cm. × 4–12 mm., *concolorous, generally clothed with white, silky threads*, more rarely flocculose, becoming smooth, enlarged upwards when growing singly, downwards when fasciculate, striate, base white villose, soon hollow, *remarkably tough*. Gills *pallid, pale yellowish, then greyish red*, decurrent, *often branched and anastomosing*, narrow, 2–4 mm. broad, *somewhat thick*, crowded. Flesh *concolorous*, thick only at the disc, *remarkably tough*. Spores white, oblong elliptic, with an oblique apiculus, 7–9 × 3–3·5 μ. Smell unpleasant or sometimes earthy. Taste unpleasant. Growing singly, fasciculately or in rings, amongst mossy grass, leaves, twigs or conifer needles in woods and pastures. Sept.—Nov. Rare. (*v.v.*)

873*. **Clitocybe vibecina** Fr. Rick. Die Blatterpilze, t. 103, fig. 5. *Vibecina*, striped.

P. 2·5–7 cm., *livid grey, becoming almost white when dry, submembranaceous*, convex, *umbilicate*, then infundibuliform, hygrophanous, glabrous, often with a silky sheen and somewhat zoned; margin *soon patent, striate* when moist. St. 5–7·5 cm. × 4–7 mm., *greyish, paler at the apex*, equal, sometimes compressed, elastic, often *flexuose*, base white villose. Gills *greyish white*, adnate, *then deeply decurrent*, 2–3 mm. broad, *somewhat crowded*. Flesh *greyish when moist, white when dry*, thick at the disc, thin at the margin. Spores white, elliptical, 5–7 × 3–4 μ. Smell earthy, mealy or none. Taste mild or slightly unpleasant. Woods, especially conifers. Not uncommon. (*v.v.*)

931*. **Hygrophorus lepidopus** Rea. λεπίς, a scale; πούς, foot.

P. 4 cm., *pale ochraceous, everywhere covered with minute, adpressed, bistre scales*, fleshy, convex, obtuse, then expanded; margin *exceeding the gills*, undulate, rimosely incised. St. 6–7 × 1 cm., *white, the basal three-fourths covered with minute, adpressed, bistre scales*, firm, tough, equal, or slightly enlarged upwards, apex white-mealy. Gills *white, or pallid*, sinuato-adnate, ventricose, 5–6 mm. broad, distant; trama consisting

of interwoven hyphae. Flesh *white*, thick at the disc, thin at the margin. Spores white, subglobose, 5–5·5 × 4–4·5 μ; basidia elongate-clavate 45–50 × 5–7 μ, with 4-sterigmata, 4–6 μ long. Cystidia none. Smell none. Taste pleasant. Pastures. Sept.—Oct. Rare. (*v.v.*)

998. **Flammula inopus** Fr. (= *Flammula fusus* (Batsch) Fr. sec. Quél., and Rick.) ἴς, a fibre; πούς, foot.

P. 5–10 cm., *honey-tan colour, paler round the margin*, fleshy, convex, then expanded, obtuse, slippery (almost viscid) when moist, and *smooth* when dry. St. 7–10 cm. × 2–4 mm., *pallid, brick colour downwards*, equal, or attenuated upwards, tough, flexuose, *adpressedly fibrillose*. Cortina fugacious. Gills *pale yellowish white, sometimes green*, adnate, linear, thin, crowded. Flesh *concolorous, becoming whitish, ferruginous in the stem*, thin at the margin. Spores dirty-ferruginous, "subelliptical, 8–9 × 4–5 μ. Cystidia flask-shaped or clavate with a prominent point, 30–36 × 10–15 μ, filled with olive-yellow juice" Rick. Solitary or caespitose. Pine trunks, stumps and on the ground. Sept.—Nov. Uncommon.

In my *British Basidiomycetae* I followed the tradition of many British mycologists and founded my description of this species on *Hypholoma radicosum* Lange (see p. 213 hereof) which has hitherto been erroneously referred to this species and consequently a redescription of *Flammula inopus* became necessary.

999*. **Flammula austera** Fr. αὐστηρά, bitter

P. 4–12 cm., *honey colour, becoming fuscous or tawny at the disc*, fleshy, campanulate, then convex and expanded, obtuse, *sprinkled with superficial fibrils*, then smooth, *hygrophanous*. St. 10–12 × 1 cm., *whitish, fibrillosely silky, becoming ferruginous* when the fibrils are worn away, equal. Cortina *white*, shining, appendiculate. Gills *cinnamon from the first*, adnate, subdecurrent, 10–12 mm. broad, crowded. Flesh whitish, thin at the margin. Spores ferruginous, oblong-elliptical, with an oblique apiculus, 8–9 × 4–5 μ, contents granular. Cystidia none. Taste acid, smell "very acid" Fr. Densely caespitose. Pine trunks and on the ground. Oct. Rare. (*v.v.*)

1024*. **Collybia infumata** (Bres.) Rea. (= *Clitocybe ectypa* Fr. var. *infumata* Bres.) Bres. Fung. Trid. t. 154, as *Clitocybe ectypa* Fr. var. *infumata* Bres. *Infumata*, smoked.

P. 4–7 cm., *whitish becoming fuscous, fuscous brown or fuscous fawn colour*, fleshy, convexo-campanulate, then expanded and umbonate or depressed, *innately fibrillose*, often reticulately fibrillose, disc punctate. St. 5–7 cm. × 6–15 mm., *whitish becoming fuscous*, equal, often becoming thickened and white

villose at the base, fibrillose. Gills *whitish, then greyish, becoming blue when touched*, adnate or sinuate, then subdecurrent, somewhat crowded. Flesh *white, becoming black* when broken, thin at the margin. Spores white, boat-shaped or subrhomboidal, ends obtuse, 9–12 × 6–8 μ, 1-guttulate. Smell and taste none. Woods and under beeches. July—Oct. Uncommon. (*v.v.*)

1226*. **Mycena lasiosperma** Bres. Bres. Fung. Trid. t. 37, fig. 1. λάσιος, shaggy with hair; σπέρμα, seed.

P. 1–2·5 cm., *livid grey, becoming somewhat yellowish, disc darker*, membranaceous, conico-campanulate, then expanded and umbonate, and finally revolute, *subviscid, at first covered with grey pruina*, becoming smooth, striate up to the umbo; margin entire, finally revolute. St. 3–4 cm. × 1–2 mm., *pallid*, "chestnut colour downwards" Bres., equal, firm, *gradually tapering downwards into the white villose, rooting base, everywhere white pruinose*. Gills *white, then greyish*, sinuato-uncinate, somewhat crowded, connected by veins. Flesh *white or subconcolorous*, thin. Smell none, or "of rancid meal" Bres. Spores white, *globose*, 5–7 μ, *verrucose*; basidia clavate, 25–35 × 7–8·5 μ, with 2-long-sterigmata. Cystidia on both gill edge and surface, elongate fusiform, ventricose below, narrowly cylindrical above, 40–95 × 5–13 μ ("40–55 × 8–14 μ" Bres.), apex obtuse, rarely somewhat branched, 2–3·5 μ in diam. Often caespitose. On stumps in woods and living mulberry trees. Oct.—Dec. Uncommon. (*v.v.*)

1277*. **Mycena trachyspora** Rea. τραχύς, rough; σπορά, seed.

P. 6–17 mm., *livid grey, or pale fuscous*, membranaceous, campanulate, then expanded, and hemispherical; margin slightly striate, often split. St. 1–3 cm. × 1–2 mm., *white, or pallid*, equal, *clothed*, under a lens, *with very delicate, hyaline, aseptate, cystidia-like hairs*, 50–70 × 6–10 μ, apex obtuse, 8–15 μ in diam. Flesh *white*, thin. Spores white, *globose or subglobose*, 5–6 × 4·5–5 μ, *verrucose*. Basidia clavate, 20–22 × 7 μ, with 4-sterigmata. Cystidia hyaline flexuose, often ventricose at base, 45–60 × 6–10 μ, apex obtuse, sometimes constricted into a globose head, 6–7 μ in diam. Old elm root. Oct.—Nov. Rare. (*v.v.*)

1288*. **Nolanea majalis** (Fr.) Konrad. Bull. Soc. Myc. Fr. XXXIX, t. 2, figs. 1–4. *Majus*, the month of May.

P. 4–9 cm., *cinnamon, or brown, becoming paler, or ochraceous when dry*, fleshy membranaceous, *conico-campanulate*, then expanded, umbonate, silky-shining when dry; margin striate when moist. St. 7–16 cm. × 4–6 mm., *greyish tawny, paler than the pileus*, shining, *twisted, striate*, somewhat fibrillose, apex farinose,

often connate at the thickened, white tomentose base. Gills *greyish*, then flesh coloured with the rosy spores, sinuato-adnate, then free, *ventricose*, 8–14 mm. broad, rather crowded, crenate. Flesh pale, very thin. Spores pink, oblong angular, 12–16 × 7–9 μ. Smell and taste often unpleasant, of fish. Heaths and coniferous woods. April—June. Uncommon. (*v.v.*)

1293*. **Nolanea cetrata** (Fr.) Schroet. Ricken, Die Blatterpilze, t. 74, fig. 1. *Cetrata*, shield-bearing.

P. 2–7 cm., *bright yellow, or yellowish cinnamon, then pale ochraceous, or greyish ochraceous when dry*, submembranaceous, campanulato-plane, then convex and expanded, obtuse, glabrous, pellucidly striate when moist, silky-shining when dry; margin *often crenulate*. St. 5–8 cm. × 2–7 mm., *pale yellow, or pale brownish ochre*, base white tomentose, subattenuated upwards, often contorted or compressed, *silky, fibrillosely striate*, brittle. Gills *yellowish flesh colour, then brown reddish flesh colour*, adnate by a tooth, nearly free, ventricose, 6–7 mm. broad, subdistant; edge *subcrenulate, becoming brownish*. Flesh watery, *very brittle*. Spores pink, oblong, mostly sexangular, 10–12 × 5–7 μ; basidia with 2–4-sterigmata ("2-sterigmata only" Schroet. and Rick.). Coniferous woods, rarely beech woods and in gardens. Aug.—Oct. Uncommon. (*v.v.*)

1407*. **Omphalia candida** Bres. Bres. Fung. Trid., t. 199. *Candida*, shining white.

P. 6–18 mm., *shining white*, membranaceous, convex, then expanded, often papillate, smooth; margin pellucidly striate. St. 4–7 cm. × 1–2 mm., *concolorous*, equal, very minutely pruinose, fibrillosely-splitting, rooting base white floccose. Gills *concolorous*, deeply decurrent, distant, veined at the base. Flesh white. Spores white, fusiform, ventricose, acute at one end, obtuse at the other, 7–10 × 3–4 μ, 1-guttulate; basidia clavate, 20–25 × 6–8 μ. Smell and taste none. On dead rhizomes of *Symphytum officinale*. Oct. Uncommon. (*v.v.*)

1411*. **Omphalia gibba** Pat. *Gibba*, a hump on the back.

Entirely white, very fragile. P. 2–4 mm., membranaceous, plane, disc gibbose, "villose and soon becoming deeply depressed" Pat., diaphanous. St. 4–6 × ·5 mm., villose, pellucid. Gills ·5–1 mm. broad, *often absent, or reduced to folds*. Spores white, oblong elliptic, attenuated at one end, straight or slightly curved, 9–12 × 3–3·5 μ ("12–15 × 3–5 μ" Pat.), basidia pyriform 6–10 × 5–6 μ, with 2–4-sterigmata, 6–7 μ long. Cystidia none. On *Cladium Mariscus, Carex, Scirpus, Sparganium* in fens and marshes. Nov. Uncommon. (*v.v.*)

1448. **Pleurotus revolutus** Kickx.

Spores white, elliptical, 6–7 × 3·5–4 μ, 2–3-guttulate.

1450*. **Pleurotus geogenius** (DC.) Fr. (= *Agaricus auricula* Pers.) Rolland, Champ. t. 44, no. 96.

γῆ, earth; γίγνομαι, to be born.

P. 3–6 cm., *pale grey, yellowish, or bistre,* fleshy, then subcoriaceous, erect, *semi-infundibuliform and incised on one side, or spathulate,* smooth, glabrous; margin at first involute, then undulato-reflexed or lobed. St. 1–6 cm. × 5–20 mm., *whitish,* lateral, *erect, strigosely white-tomentose,* base attenuated or bulbous, with numerous white, string-like mycelial threads. Gills *white, then subalutaceous,* decurrent, crowded, narrow, sometimes forked. Flesh *white, with a gelatinous layer under the cuticle of the pileus.* Spores white, obtusely elliptical, often apiculate at the base, 7–8 × 5 μ, 1–2-guttulate. Cystidia *very abundant on the surface of the gill,* hyaline, fusiform, 50–80 × 12–16 μ, apex obtuse, 4–5 μ in diam., very thick walled, often rough at the apex. Smell *strong of new meal.* Taste pleasant. Edible. Often densely caespitose. On the ground in woods and on sawdust heaps. Aug.—Oct. Locally common. (*v.v.*)

1537*. **Russula constans** (Karst.) Romell (= *Russula flava* Romell sec. Kauffman; non *Russula constans* Britz.)

Constans, unchangeable.

P. 5–10 cm., *apricot colour with a tinge of pink round the margin, then yellow* (luteus), convex, then expanded, often becoming depressed in the centre, viscid; pellicle separable, possessing cystidia; margin thin, striate. St. 4–8 × 1–3 cm., *white, becoming cinereous or blackish with age,* equal, or slightly incrassated at the base, somewhat striate. Gills *cream colour, becoming cinereous or blackish when dried,* adnate, broad in front, attenuated behind, 8–12 mm. broad, forked at the base, connected by veins, somewhat crowded. Flesh *white, soon becoming brownish and finally cinereous or blackish.* Spores *pale cream colour in the mass,* subglobose, or broadly elliptical, 9–12 × 7–9 μ, verrucose; basidia clavate, 25–39 × 8–9 μ ("35–38 × 10–11 μ" Karst.), with 4-sterigmata, 3–4 μ long. Cystidia abundant, elongate-flask-shaped, cylindrical or more rarely fusiform, 28–55 × 5–13 μ ("65–72 × 11–12 μ" Karst.), apex 2–3 μ in diam., contents yellowish. Smell none. Taste *mild.* Moist places in deciduous and coniferous woods. Aug.—Oct. Not uncommon. (*v.v.*)

1546*. **Russula paludosa** Britz. Britz. Hym. Südbay. Russula, nos. 23, 60, 96.

Paludosa, marshy.

P. 3·5–12 cm., *red, reddish orange or purplish copper colour*, rarely becoming decoloured and *greenish yellow at the margin or at the disc*, convex, sometimes umbonate, then plane and depressed, slightly fleshy, *viscid, pellicle separable* or only so to the disc; margin rounded, *generally tuberculosely sulcate*, or only striate when old. St. 5–15 × 1·5–2·5 cm., *white tinged with rosy purple, or entirely white, attenuated at the apex*, widening out at the base of the gills, gradually enlarged downwards to almost twice its breadth at the base, pruinose when young, more or less rugosely striate. Gills *white, then ochraceous from the spores, often coloured reddish on the edge near the margin of the pileus*, free or almost free, rounded in front, attenuated behind, equal, rarely unequal, often furcate near the margin, broad, thin, rather crowded. Flesh *white, slightly reddish under the cuticle of the pileus*, firm, brittle, then soft and fragile. Spores *cream colour in the mass*, pale yellowish under the microscope, elliptical, or oblong, 8–12(–14) × 7–9 μ, *echinulate, sometimes marked with ridges*, 1-guttulate. Cystidia clavate, 60–100 × 8–11 μ. Smell weak. Taste mild, or often slightly acrid when quite young. Coniferous woods and peat bogs. June—Nov. Uncommon. (*v.v.*)

1562*. **Lactarius resimus** Fr. Fr. Icon. t. 168, fig. 1.
Resimus, bent back.

P. 7–13 cm., *pallid, or pale ochraceous, becoming yellowish with age*, fleshy, convex, umbilicate, then infundibuliform, very viscid, *smooth*, zoneless; *margin involute, white tomentose*, then expanded and smooth. St. 3–4·5 × 2–3·5 cm., *concolorous*, somewhat attenuated at the base, villose, very finely pubescent under a lens. Gills *whitish*, decurrent, 5–8 mm. broad, somewhat crowded. Flesh *pallid, becoming yellow when broken*. Milk *white, becoming immediately deep sulphur-yellow* when exposed to the air. Spores *ochraceous*, globose, 6–7 × 6 μ, obtusely echinulate, 1-guttulate. Taste acrid. Woods on calcareous soil. Aug.—Oct. Uncommon. (*v.v.*)

1694*. **Coprinus Boudieri** Quél. Bull. Soc. Bot. Fr. XXIV, t. 5, fig. 5. Émile Boudier, the eminent French mycologist.

P. 1–2 cm., *pale tawny, disc fuscous, soon becoming blackish with a tawny disc*, ovoid, campanulate, 2–3 cm. high, *striate, then furrowed, sparsely covered with a delicate, white pubescence*; hairs hyaline, ventricose at base, 30–50 × 8–10(–18) μ, apex obtuse, 3–4 μ in diam. St. 3–8 cm. × 2–4 mm., *white*, slightly attenuated upwards, rigid, pruinose, pubescent. Gills *cream colour, then grey, at length violet-black*, adnate, linear, crowded; *margin white, micaceous*. Flesh *white, somewhat tawny at the*

fleshy disc. Spores fuscous, *mitriform*, 8–10 × 6·5–7·5 μ. Cystidia "30–36 × 15–30" Rick. Burnt earth and charcoal heaps in woods and pastures. July—Oct. Not uncommon. (*v.v.*)

1714*. **Marasmius gelidus** Quél. Boud. Icon. t. 74.
Gelidus, icy cold.

P. 1–3 cm., *very pale fawn, or flesh colour, disc darker*, membranaceous, campanulate, then expanded, slightly umbonate, often finally depressed; margin *rugosely striate*, hygrophanous, pruinose in dry weather. St. 5–7 cm. × 2–3 mm., *fawn colour tinged reddish*, equal, often incurved at the base and attached by a copious mycelium to the dead leaves, *covered with a delicate pubescence* which becomes longer and denser towards the base. Gills *paler than the pileus*, free, thin, fairly wide, *connected by veins*. Flesh *pallid, reddish in the stem*. Spores white, oblong, attenuated at one end, slightly incurved, 8–10 × 3·5–4 μ, contents granular. Smell none. Often fasciculate. Amongst leaves in woods. Nov.—Dec. Uncommon. (*v.v.*)

1806*. **Craterellus amethysteus** Rea. ἀμέθυστος, amethyst.

P. 1–2·5 cm., *tawny, paler at the margin*, fleshy membranaceous, convex, umbilicate, then somewhat infundibuliform, glabrous. St. 1–3 cm. × 3–4 mm., *tinged lilac*, gradually expanded into the pileus, often attenuated downwards, smooth. Hymenium *lilac*, wrinkled. Flesh *lilac* in the pileus and upper portion of the stem, *whitish* elsewhere, very thin except at the disc. Spores white, *globose*, 7–8 μ, *minutely echinulate*. Woods. Sept.—Oct. Rare. (*v.v.*)

1890*. **Boletus rhodoxanthus** (Krombh.) Kallenbach. (= *Boletus sanguineus rhodoxanthus* Krombh.; *Boletus purpureus* Fr. p.p.) Kallenb., Die Pilze Mitteleuropas, Band 1, Die Rohrlinge (Boletaceae), t. 2, fig. 3, t. 4, figs. 1–11.
ῥόδον, rose; ξανθός, yellow.

P. 5–20 cm., *pallid, yellowish white to pale brownish yellow, often suffused with rose colour, becoming darker when handled or weathered*, convex, then hemispherical, pulvinate, *delicately tomentose* under a lens, becoming somewhat viscid, smooth and ragged; margin *often rosy*, at first incurved, then irregular. St. 4–13 × 3–6·5 cm., *bright golden yellow, beautifully reticulated with blood red veins and dots, apex golden yellow, becoming reddish towards the greyish white, attenuated base, becoming bluish green by pressure*, ovato-ventricose, *then cylindric-clavate or subcylindrical*, arising from a *pale yellow mycelium*. Tubes *yellow, or greenish yellow, becoming bluish green* by handling or on section, somewhat free, short, then elongate; orifice of pores *lemon- or golden-yellow, then bright blood-red* with the exception of a marginal zone, and finally

darker and more olivaceous, becoming *bluish green when touched*, round, angular, minute. Flesh *lemon- or golden-yellow*, somewhat *reddish under the cuticle of the pileus and at the base of the stem, becoming bluish on exposure to the air, especially at the base of the tubes and apex of the stem, then paler and finally dirty yellow*, but remaining *bright golden-yellow* where eaten by slugs or otherwise injured, firm, *soon soft and spongy*. Spores olivaceous in the mass, yellow under the microscope, oblong elliptic, 9–11 × 4·5–5 μ ("elliptic fusiform, (9) 10–14(–16) × 4–5 μ" Kallenb.). 2–3-guttulate. Taste mild. Deciduous woods, especially beech and oak. July—Sept. Uncommon. (*v.v.*)

1943. **Polyporus amorphus** Fr.

Spores white, cylindrical, curved, 3–4 × 1 μ.

1949. **Polyporus lacteus** Fr.

Spores white, cylindrical, slightly curved, 3·5–4·5–7 × 1–1·5 μ, with a guttula at each end.

1978*. **Fomes pinicola** (Swartz) Fr. Gillet, Hymén. t. 464.
Pinus, pine; *colo*, I inhabit.

P. 10–50 cm., *white, becoming tawny or reddish, and finally black*, applanate, dimidiate, or hoof-shaped, *covered with a thin, resinous crust*; margin *whitish*, obtuse. Tubes *pale yellow*, 5–25 mm. long, harder than the flesh; orifice of pores *whitish, becoming yellowish*, minute, round. Flesh *pale yellow*, soft, firm. Spores white, obovate, 7–10 × 3·5–4 μ. Smell acid. Conifer trunks, more rarely on frondose trees. Jan.—Dec. Rare. (*v.v.*)

1997*. **Poria xantha** (Fr.) Lind. *ξανθή*, yellow.

P. 4–10 cm., *white, or pale sulphur-yellow*, effused, forming confluent patches, 2–5 mm. thick, immarginate. Pores *white, becoming pale sulphur-yellow*, round, or elongate, often oblique, thin, dissepiments fairly thick. Spores hyaline, allantoid, 4–6 × 1·5 μ. Hyphae flexuose, thick walled, 2–4 μ in diam., without clamp connections. On frondose and coniferous wood. Jan. Uncommon. (*v.v.*)

2058*. **Lenzites albida** Fr. Fr. Icon. t. 177, fig. 1.
Albida, whitish.

P. 4–6 cm., *milk white*, corky coriaceous, soft, dimidiate, sessile, becoming plane, sometimes effuso-reflexed, often imbricate, *zoneless, densely covered with a white, adpressed tomentum*, becoming silky with age and almost smooth. Gills *concolorous*, thin, dichotomous, often anastomosing and pore-like, edge entire. Flesh white, firm. Spores white, oblong, often slightly curved, 8–9 × 4–4·5 μ. On ash and birch trunks. Oct.—Feb. Rare. (*v.v.*)

2202*. **Odontia junquillea** Quél. Bull. Soc. Myc. Fr. XLII, t. 7, figs. 24–26. *Junquillea*, bright yellow.

R. 3–6 cm., *hyaline flesh colour, becoming cream-jonquil, isabelline, or tan colour*, effused, silky with hyaline hairs under a lens, then thickened, crustaceous and cracked; margin *white*, pruinose or subfibrillose. Spines *concolorous*, rigid, short, deformed, apex hispid. Flesh *concolorous*, waxy, then crustaceous, thick. Spores white, elliptical, attenuated at the base, 5–8–12 × 3·5–7·5 μ, 1-multi-guttulate; basidia 16–30–75 × 5–6–9 μ, with 2–4-sterigmata, 4–7 μ long. Cystidia very distinct at first, cylindrical, or narrowly clavate, 60–100 × 6–12 μ, *rugose*, then *adhering in fascicles, incrusted with large, split, oxalate crystals forming in their axis granular bands*, 150–200 × 9–24 μ. Hyphae thin walled, 2–6 μ in diam., at first very distinct, then collapsed, clamp connections frequent or rare. Deciduous and coniferous wood, shrubs and herbs. Jan.—Dec. Common. (*v.v.*)

2233*. **Hypochnus phylacteris** (Bull.) Rea. (= *Tomentella phylacteris* (Bull.) Bourd. & Galz.) Bull. t. 436, fig. 2.
φυλατήρ, a guard.

R. 2–10 cm., *grey, becoming brownish black*, broadly effused, membranaceous, adnate or separable, subiculum finally very thick, firm, densely felted; margin *whitish or concolorous*, villose or shortly fibrillose. Hymenium *greyish white, nut colour, smoky (very pale azure blue when fresh), becoming fuliginous, or remaining pale*, pruinosely mealy. Flesh *brownish bistre*, floccose, thick. Spores *brownish bistre*, with thin, short spines, globose, or oval, regular or sinuose, often obtusely mucronate, 7–9–15 × 6–8–10 μ; basidia, 25–60–75 × 6–10–16 μ, with 2–4-sterigmata, 6–8 μ long. Hyphae 3–9 μ in diam., *without clamp connections*, basal hyphae brownish bistre, firm, slightly thick walled, upper hyphae subhyaline, denser, frequently septate. Damp wood, bare soil, stumps and trunks of trees. Nov. Uncommon. (*v.v.*)

2238*. **Hypochnus tulasnelloideum** (von Hoehn. & Litsch.) Rea. (= *Corticium tulasnelloideum* von Hoehn. & Litsch. Beitr. zur Kennt. der Cort. in Sitzungsber. der k. Akad. d. Wissensch. Wien, Math-Nat. Kl. Bd. CXVII (1908), 1118, text-fig. 10, and Trans. Brit. Myc. Soc. VIII, 217, text-fig. 3.)
Tulasnella, the genus *Tulasnella*; εἶδος, like.

R. 1–3 cm., *mouse grey to bluish grey*, effused, very thin, closely adnate, *appearing like a pruinosity on the surface of the matrix*. Hymenium *concolorous*, smooth and continuous when best developed. Spores hyaline, very finely and closely echinulate, broadly elliptical to subglobose, 4·5 × 3 μ or 4 μ in diam.

("3·5–6 × 3–4·5 μ" von Hoehn & Litsch.); basidia clavate, 12–20 × 6–8 μ, with 2–4-sterigmata, 6–7 μ long. Hyphae distinguished with difficulty, "2·5 μ in diam. with clamp connections" Bourd. & Galz. Rotten, decorticated wood. Oct.—March. Rare.

Tomentellina von Hoehn & Litsch.

(*Tomentellina*, diminutive of *Tomentella*, a synonym of *Hypochnus*.)

Same characters as *Hypochnus* but *possessing cystidia.*

2239*. **Tomentellina ferruginosa** von Hoehn. & Litsch. Beitr. zur Kennt. der Cort. in Sitzungsber. der k. Akad. d. Wissensch. Wien, Math-Nat. Kl. Bd. cxv (1906), 1604, text-fig. 9. *Ferruginosa*, iron rust colour.

R. 5–10 cm., *rust-yellow to dark brown*, effused, floccose, soft, adnate, easily separable; margin generally *brighter in colour*, similar, or slightly radially fibrillose. Hymenium *concolorous*, discontinuous, becoming denser and granular, *velvety*. Spores yellow brown to brown, verrucose, warts short, blunt, subglobose or angularly globose, 6–9 μ, 1-guttulate; basidia clavate, 20–25 × 6–8 μ, with 4 straight or slightly bent, pointed sterigmata, 4–8 μ long. Cystidia *brown*, numerous, separate or in fascicles, narrowly cylindrical, slightly wider above, 120–200 × 5–8 μ, protruding up to 140 μ above the hymenium, obtuse, septate, thick walled. Hyphae bright yellow to yellow-brown, thin walled, 3–7 μ in diam., septate, without clamp connections; basal hyphae joined together in more or less thick, anastomosing cords. Rotten wood. Jan.—Dec. Not uncommon. (*v.v.*)

2253*. **Stereum insignitum** Quél. *Insignitum*, distinguished.

R. 3–6 cm., *bright tawny, or tawny rust colour, becoming brownish or grey, with concolorous or differently coloured zones*, reflexed, shell-shaped or fan-shaped, sometimes attenuated into a lateral, stem-like base, tomentose, becoming glabrous or satiny. Hymenium *pale, boxwood colour, ochraceous cream or leather colour*. Flesh *yellowish*, coriaceous, thin, intermediate layer bordered next to the tomentose surface by a golden zone and composed of flexuose, longitudinally arranged hyphae, which are either thick walled, 4–7 μ in diam., or thin walled, 3–4 μ in diam., and terminate in cystidia. Spores white, elliptical, or subcylindrical, slightly depressed on one side, 5–6 × 2·5–3 μ, basidia clavate, 20–35 × 3–5 μ, with 4-sterigmata. Dead beech branches and stumps. Jan.—Dec. Not uncommon. (*v.v.*)

Asterostromella von Hoehn. & Litsch.

(*ἀστήρ*, star; *στρῶμα*, a bed, a stroma.)

Receptacle membranaceous, crustaceous, or floccose, resupinate, effused. Hymenium smooth, farinose or pubescent. Spores white, oboval, oblong, fusiform, clavate or subglobose, smooth; basidia *scattered*, with 2–4-sterigmata, *greatly exceeding the hyaline or coloured, dichotomously branched, dendroid sterile mycelium or paraphyses*. Growing on wood, leaves, or on the ground.

2278*. **A. ochroleuca** Bourd. & Galz.

ὠχρός, pale; *λευκός*, white.

R. 1–4 cm., *ochraceous cream colour*, effused, incrusting, soft; margin *white*, fibrillose or pruinose. Hymenium *concolorous*, pelliculose, fragile. Spores hyaline, *subglobose*, very shortly apiculate at the base, 3–4 × 2·75–3 μ; basidia clavate, 15–23 × 4–4·5 μ, with 2–4 straight sterigmata, 4·5–6 μ long. Gloeocystidia sparse, fusiform, 18–36 × 6–7 μ, contents hyaline. Basal hyphae firm, very thin, ·5–1 μ in diam., branched; upper hyphae 2–3 μ in diam., branched, branches rigid, dichotomous, divaricate. Twigs, fallen branches, the ground and stones. Nov.—March. Uncommon. (*v.v.*)

2292*. **Corticium bisporum** Bourd. & Galz. Trans. Brit. Myc. Soc. VIII (1923), text-fig. 1, p. 216. *Bis*, twice; *σπορά*, seed.

R. 2–6 cm., *white to cream colour*, effused, indeterminate, easily separable, very thin. Hymenium *concolorous*, forming a continuous pellicle above the loose cottony subiculum, often wrinkled or rather bullate when fresh but becoming smooth when dry. Spores hyaline, ovate, elliptical, or somewhat oblong, 8–11 × 4·5–6 μ, smooth; basidia arising from branched hyphae in a corymbose manner, clavate, 15–25 × 6–7·5 μ; sterigmata *constantly* 2, short 4–5 μ, divergent. Basal hyphae very loosely interwoven, septate, very rarely having clamp connections, 4–6 μ in diam. Rod-shaped crystals abundant in subhymenial tissue. Fallen branches. Uncommon.

2294*. **Corticium byssinum** (Karst.) Massee.

βύσσινος, made of fine linen.

R. 2–5 cm., *white, or cream colour*, irregularly effused, pelliculose, or submembranaceous, subadnate, fragile; margin byssoid or fibrillose. Hymenium *concolorous*, mealy. Subiculum arachnoid. Spores white, "*subglobose or ovoid*, 2·5–4 × 2–3 μ, often 1-guttulate, basidia 9–18 × 3–4·5 μ, with 2–4-sterigmata, 2–4 μ long. Hyphae rather rigid, regular, 2–3 μ in diam., *without clamp connections*, often granular or rough with rod-like crystals"

Bourd. & Galz. Fallen sticks, humus, etc. Sept.—April. Uncommon. (*v.v.*)

2296*. **Corticium diademiferum** Bourd. & Galz. Trans. Brit. Myc. Soc. VIII, text-fig. 2, p. 217.

διάδημα, a band; *fero*, I bear.

R. *whitish to cream colour*, effused, very thin, margin indeterminate. Hymenium *concolorous*. Spores *subglobose*, 4–5 × 3–4 μ; basidia 15–21 × 5–6 μ, with 6–8-sterigmata. Hyphae thin walled, with clamp connections, 3–5 μ in diam. Bark of birch log. March. Rare.

2336*. **Peniophora miniata** (Berk.) Burt.*.

Miniata, coloured with red-lead.

R. 2–10 × 1–2·5 cm., *English red*, effused, tender; margin byssoid or fibrillose, often connected with blood red mycelial strands. Hymenium *concolorous, often drying pinkish buff to buff pink and cinnamon rufous*. Flesh 150–300 μ thick, *not coloured*, submembranaceous, arachnoid. Spores white, elliptical, 4–4·5 × 2–2·5 μ. Cystidia few, *not incrusted*, hair-like, protruding 20–30 × 3·5–4·5 μ above the hymenium. Hyphae loosely arranged, 3–6 μ in diam., not incrusted, rarely with clamp connections. Fallen limbs, usually of Conifers. July—Dec. Uncommon. England, Berkeley, British Fungi exsiccati, no. 251.

2391*. **Phaeocyphella episphaeria** (Quél.) Rea. (= *Calyptella episphaeria* (Mart.?) Quél.)

ἐπί, upon; *sphaeria*, the genus *Sphaeria*.

R. 1–2 mm., *white*, cup-shaped, sessile, externally *densely covered with long, flexuose, rough hairs*; hairs hyaline, often incurved at the apex, somewhat coloured towards the base, 40–70 × 3 μ. Hymenium *grey*, concave, even. Flesh *grey*, thin. Spores pale yellow-brown, broadly elliptical, obtuse, 8–9 × 5–5·5 μ; basidia 25–35 × 4–5 μ, with 4-sterigmata. Fallen branches attacked by *Sphaeria*. Nov.—April. Uncommon. (*v.v.*)

2411*. **Clavaria pallida** (Schaeff.) Bres. Bull. Soc. Myc. Fr. XLI (1925), Atlas, t. 3. *Pallida*, pale.

R. 6–8 cm. high, 2–4 cm. broad, *ochraceous cream, tinged with flesh colour upwards*; trunk 2–4 × 2–4 cm., *ochraceous cream, or pale coffee and milk colour, whitish at the base*, divided into numerous, erect, somewhat crowded, stout branches; branches *ochraceous cream, tinged with flesh colour*, dichotomous, sometimes slightly curved at the forks, cylindrical or compressed,

* The Thelephoraceae of North America, XIV (1926), Ann. Missouri Bot. Gard. XII (1925), *Peniophora*, 277.

rugose, especially longitudinally; apices often tinged with lilac when young, toothed, short, *obtuse*. Flesh *white*. Spores pale ochraceous in the mass, elliptic-oblong, obliquely apiculate at the base, 9–12 × 4·5–5 μ, 1–2-guttulate, becoming finally minutely verrucose; basidia clavate, 75–90 × 8–9 μ, with 2–4-sterigmata, 8–9 μ long. Smell faint. Taste sweet then bitter. Coniferous woods. Sept.—Oct. Uncommon. (*v.v.*)

2441*. **Clavaria truncata** Quél. (= *Craterellus pistillaris* (Schaeff.) Fr.) Bull. Soc. Myc. Fr. XXXIX, t. 3, figs. 1–4.
Truncata, maimed.

R. 6–15 cm. high, 2–9 cm. broad, *yellow, or ochraceous orange, becoming ochraceous or rufescent, turbinately clavate, apex truncate from the first*, then more or less hollowed out, rarely rounded or deformed; generally irregularly rugosely sulcate, pruinose, gradually attenuated downwards to the whitish base, rarely slightly rooting, arising from a network of white, cord-like mycelium. Flesh *whitish or ochraceous, turning slightly brownish violaceous on exposure to the air*, fibrillosely fleshy, firm, becoming spongy inside, cortex brittle. Spores pale ochraceous in the mass, hyaline, elliptic-oblong, with a sublateral apiculus, 9–13 × 5–6 μ, 1-multi-guttulate. Smell scarcely any. Taste *sweet*, sugary. Edible. Coniferous woods. Sept.—Oct. Uncommon. (*v.v.*)

2446*. **Clavaria luticola** (Lasch) Fr.
Lutum, mud; *colo*, I inhabit.

R. 5–20 mm. high, ·5–1 mm. thick, *yellowish, becoming brownish, apex often whitish*, simple, obtuse, attenuated downwards to the white villose base. Flesh somewhat fragile. Spores white, subglobose, 5–6 × 4–4·5 μ; basidia cylindrical, 8–12 × 4 μ, with 2 long sterigmata. Cystidia flask-shaped, 16–18 × 5–6 μ, apex obtuse, 3 μ in diam. Hyphae 2–3 μ in diam. Bare damp soil in woods. Sept. Rare. (*v.v.*)

***Black.

2452*. **Clavaria Greletii** Boud. Bull. Soc. Myc. Fr. XXXIII (1917), t. IV, fig. 4.
L'abbé L. J. Grélet, the eminent French mycologist.

Entirely black. R. 3–5 cm. high, 1–2 mm. thick, simple, elongate, slender, not fistulose. St. *fuliginous*, base *white*, short, glabrous. Flesh *fuliginous*. Spores white, globose, 7–8 μ, contents granular; basidia 17 × 4 μ, with 4-sterigmata. On the ground and old charcoal heaps. Oct.—Nov. Rare. (*v.v.*)

2458*. **Typhula candida** Fr. Fr. Icon. t. 200, fig. 3.
Candida, shining white.

R. 1–4 mm. high, *shining white*, club obovate, obtuse, rarely

subfusiform, sometimes bifid. St. *whitish, or reddish,* distinct, *glabrous,* or with a few scattered hairs which are gibbous at the base, *rough with oxalate granules.* Spores white, oblong-elliptic, attenuated and slightly bent at the base, 6–9 × 3–4 μ; basidia clavate, 15–33 × 4–6·5 μ, with 2–4-sterigmata. Hyphae thin walled, 3–15 μ in diam. Dead leaves, especially alder, ash, oak and willow. Oct.—Dec. Common. (*v.v.*)

Pistillina Quél.

(*Pistillina,* a little pestle.)

Receptacle minute, erect or pendant, somewhat firm, *pin-shaped,* stem cylindrical, smooth or villose, enlarged at the apex into a convex disc covered by the hymenium, which is sometimes ciliate at the margin. Trama filamentous, like *Pistillaria.* Spores white, oval, smooth; basidia with 2–4-sterigmata. Epiphytes, or growing on dead leaves.

2473*. **Pistillina hyalina** Quél. Quél. Ass. Fr. 1880, t. 8, fig. 12.
Hyalina, transparent.

R. 1–2 mm. high, *entirely white and diaphanous.* Disc 2–3 mm. wide, *hemispherical, then lens-shaped,* moist, then pruinose. St. very thin, dilated at the apex, base bulbous, puberulent with very narrow, thread-like hairs, –150 × 1–2 μ. Spores white, cylindrical, slightly curved, 7–9·5 × 3·5–4·5 μ; basidia 6–7 μ in diam., with 4-sterigmata, 6–7 μ long. Hyphae parallel, thin walled, interwoven at the base of the stem, expanding at the disc into a pseudoparenchyma composed of interwoven, closely compacted, thick walled, mucilaginous hyphae, containing numerous calcium oxalate crystals. Dead grasses and leaves. Feb. Uncommon. (*v.v.*)

2473**. **Pistillina Patouillardii** Quél. Pat. Tab. Analyt. Fung. t. 60, as *Sphaerula capitata* Pat.
N. Patouillard, the eminent French mycologist.

R. 1·5–2 mm. high, *entirely white.* Disc *globose,* ·3–·6 mm. in diam., *umbilicate beneath,* fragile, pruinose. St. diaphanous, very thin, equal, base abrupt, sparsely pubescent with simple or slightly branched, unicellular, capillary hyphae, –100 × 2–3 μ at base, apex 1–2 μ in diam. Spores white, elliptical, with an oblique basal apiculus, flattened on one side, 7·5–10 × 3·5–4 μ; basidia clavate, broadest just below the apex, 24–33 × 7·5–10 μ, with 2–4-sterigmata, straight or curved, 5–6 μ long. Hyphae parallel, thin walled, with numerous clamp connections, shorter and yellowish brown at the base of the stem, up to 17 μ in diam., becoming longer and narrower upwards and only 3·5–5 μ in diam. at the apex. Dead leaves and stems of *Phragmites* and *Rubus.* Aug.—Nov. Uncommon. (*v.v.*)

SEPTOBASIDIINEAE.

Saprophytes, with probasidia.

SEPTOBASIDIACEAE.

Same characters as suborder.

Saccoblastia Moeller.

(*σάκκος*, a bag; *βλαστός*, shoot.)

Receptacle floccose, or gelatinous, effused. Basidia cylindrical, transversely septate, arising from a probasidium, which remains as a lateral, sac-like attachment at the base of the basidium; sterigmata lateral. Spores hyaline, smooth. Growing on wood.

2477*. **Saccoblastia sebacea** Bourd. & Galz. Trans. Brit. Myc. Soc. VIII, text-fig. 4, p. 218. *Sebacea*, tallow.

R. 1–6 cm., *greyish*, effused, thin, fleshy, at first rather firm in texture, later becoming slimy-gelatinous. Hymenium *concolorous*, delicately pruinose and somewhat granulose under a lens when in good condition. Probasidium ovoid to oblong, 15–25 × 7–9 μ, pendulous, collapsing as the basidium matures and often breaking away in the preparation of sections. Spores hyaline, broadly elliptical, laterally apiculate, 7–10 × 4·5–7 μ, smooth, germinating immediately to produce secondary spores of similar form; basidia cylindrical, curved, 5–8 μ wide above, narrowing gradually to a more or less elongated pedicel below, with 2–3-transverse septa in the upper part; sterigmata lateral, conical, 8–10 × 2 μ. Hyphae frequently septate, without clamp connections, often constricted at the septa, 3–5 μ in diam., contents, as also those of the probasidium and young basidia, granular and with numerous oil drops. Old beech, birch and oak stumps. Oct.—April. Not uncommon. (*v.v.*)

2479*. **Platygloea Peniophorae** Bourd. & Galz. Trans. Brit. Myc. Soc. VIII, text-fig. 5, p. 219.
Peniophora, the genus *Peniophora*.

R. *whitish to pale buff*, starting as small patches, then becoming effused; margin *white*, somewhat byssoid. Hymenium *concolorous*, pruinose under a lens, but interrupted here and there by masses of spores (conidia?) which are aggregated in semi-liquid globules. Spores hyaline, elliptical, with one side depressed, and with a pronounced lateral, oblique apiculus, 8–9 × 5–5·5 μ, germinating to form secondary spores of similar size and shape; basidia curved, transversely 2–3-septate, 5 μ wide; sterigmata filiform, flexuose, up to 40 μ ("90 μ and more"

Bourd. & Galz.) long. Growing over the hymenium of *Corticium praetermissum* (Karst.) Bres. and probably also of *Peniophora pubera* (Fr.) Sacc. March. Rare.

2479**. **Platygloea vestita** Bourd. & Galz. *Vestita*, clothed.

R. *dirty white, hyaline*, effused, slimy-gelatinous or somewhat waxy, somewhat thick, often evanescent when dry, *clothed with white, loosely interwoven threads*. Hymenium *concolorous*. Spores hyaline, oblong-elliptical or subcylindrical, obliquely acute at the base and depressed on one side, 18–25 × 6–7 μ ("15–21–30 × 5–7·5–9 μ" Bourd. & Galz.); basidia obovate, then cylindric-clavate, transversely 1–3-septate, 40–50 × 8–10 μ; sterigmata conical, then slender, up to 20 μ long.. Mycelial hyphae, 8–10 μ in diam., thin walled, enodulose, giving rise to *erect*, flexuose, *torulose* branches, 60–100 × 6–10 μ, protruding to 40–50 μ above the hymenium. Rotten beech wood. Jan.—Dec. Uncommon. (*v.v.*)

2481. **Auricularia auricula-Judae** (Linn.) Schroet. var. **lactea** Quél. *Lactea*, milk-white.

Differs from the type in the *whitish straw-coloured receptacle, and snow-white hymenium*. Old elders. Nov.—May. Uncommon. (*v.v.*)

2497*. **Tremella glacialis** Bourd. & Galz. *Glacialis*, icy.

R. ·4–1 mm., *limpid*, shining when dry, not melting away, soon reticulately or areolately touching, not truly confluent. Flesh waxy, subcartilaginous. Spores hyaline, oblong, acute at the base, often laterally subdepressed, 5–6–8 × 3·5 μ, germinating on the side; basidia ovoid, 7–10 × 5–8 μ, 2(–4) subulate sterigmata, 10–20 × 1–1·5 μ. Hyphae scarcely distinct, 1–2 μ in diam. Moist rotten wood. Jan.—Dec. Uncommon.

2522*. **Tulasnella violacea** (Johan Olsen) Juel. Trans. Brit. Myc. Soc. VIII, text-fig. 6, p. 220. *Violacea*, violet.

R. 1–6 cm., *deep violet, drying to pale lilac*, effused, very thin. Hymenium *concolorous*. Spores hyaline, *subfusiform, curved*, 8–10 × 6–7 μ ("15 × 8 μ" Juel.); basidia subglobose to oblong, 12 × 8–11 μ; sterigmata 8–10 × 6–7 μ. Basal hyphae septate, without clamp connections, 4–5 μ in diam. Bark of old birch log. Jan.—March. Rare. (*v.v.*)

2522**. **Tulasnella allantospora** Wakef. & Pears. Trans. Brit. Myc. Soc. VIII, text-fig. 7, p. 220.

ἀλλᾶς, sausage; σπορά, seed.

R. *hyaline, or with a very faint pinkish or lilac tinge*, effused, waxy, very thin. *Hymenium concolorous*. Spores hyaline, *cylin-*

drical, curved, attenuated at both ends, 9–10 × 3–4 μ; basidia obovate, 7–10 × 6 μ; sterigmata elliptical, 7–9 × 5 μ. Basal hyphae septate, 2–3 μ in diam., no clamp connections. Decorticated coniferous wood. Feb.—April. Uncommon. (*v.v.*)

2523*. **Tulasnella microspora** Wakef. & Pears. Trans. Brit. Myc. Soc. VIII, text-fig. 8, p. 220.

μικρός, small; σπορά, seed.

R. *pale lilac,* effused, very thin, pulverulent. Spores hyaline, *ovate,* 5·5–6 × 3–3·5 μ; basidia obovate or elliptical, 7–10 × 5–6 μ; sterigmata elliptical, 2·5–3·5 × 2–3 μ. Basal hyphae branched, septate, 2–3 μ in diam., no clamp connections Rotten coniferous wood. March—April. Rare.

Subgen. **Gloeotulasnella** von Hoehn. & Litsch.

(γλοιός, sticky; *Tulasnella,* the genus *Tulasnella.*)

Differs from *Tulasnella* in possessing gloeocystidia.

2524*. **Tulasnella** (**Gloeotulas.**) **cystidiophora** von Hoehn. & Litsch. Beitr. zur Kennt. der Cort. in Sitzungsber. der k. Akad. d. Wissensch. Wien, Math-Nat. Kl. Bd. CXV (1906), 1557, 1558, 10, 11, text-fig. 1.

Cystidium, cystidium; φέρω, I bear.

R. 1–10 cm., *bluish grey, becoming black when dry,* irregularly effused, adnate, thin. Hymenium *concolorous,* loose, not continuous. Flesh gelatinous or waxy, finally collapsing when dry into a crust-like film. Spores white, oval, oblong or globose, 10–13 × 8–11 μ, with 4 oval sterigmata. Gloeocystidia *very variable in size and shape,* often very flexuose, 10–30 × 7–11 μ, filled with little oil globules. Hyphae hyaline, smooth, septate, 2–4 μ in diam., with a few, sparse clamp connections. Poplar bark. Nov.—Jan. Uncommon. (*v.v.*)